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TRANSPORTER BRIDGES

By Henry Grattan Tyrrell, C.E.

Transporter bridges of one kind or another have been in use for many centuries. The earliest ones are probably those of India, called by the natives "tarabita," and used by them for crossing streams or mountain gorges. They consisted of a single rope made of hides or fibres fastened at the ends to trees on shore, and from this rope a basket was suspended and drawn back and forth by a smaller cord. Similar bridges are known to have been used many centuries ago by the natives of Peru and adjoining countries in South America.

A contrivance of this kind, though with more detail, was used by Faustus Verautius about 1620. Wooden posts or towers were planted at each side of the stream, and between the tops of the posts was stretched a rope or cable from which a basket or car was suspended by two trolleys, one attached to each end of the conveyor. Landing platforms or brackets were fastened to the towers at the proper elevation to correspond with the floor of the moving car, and these platforms were reached by wooden ladders from the ground. A smaller endless hauling rope passing over a pulley on the top of each tower, hung loosely in the car, and by means of this rope, the car and its load was drawn back and forth by one of the occupants. These early inventions are the prototypes of the more elaborate modern cableways and transporter or ferry bridges.

The principles contained in the primitive bridges described above, were revived in England during the first part of the nineteenth century, when patents were granted to Smart, Fisher & Leach for three different types of railroad drawbridges. Drawings and models were made in 1822 for Smart's bridge, and Fisher's patent for an aerial ferry was taken out two years later, but more elaborate drawing, though somewhat similar to Smart's, was that proposed by Harvey Leach for a suspension railway ferry. His plan showed a series of spans 300 to 400 feet in length, above which cables were suspended which supported a horizontal track or runway high enough above water to leave the desired head room below, for ships and river craft. From the upper runway, a platform the full length of one span was suspended between the piers, and this platform, with its load, was capable of being moved back and forth as desired.

A patent for an aerial railway bridge to cross the East River at New York was granted about 1852 to H. N. Houghton, of Bergen, N.J., who proposed placing a number of heavy stone piers in the river, with truss spans thereon, and a clearance under the spans of 150 to 200 feet for ships. Instead of expensive approaches to a high level bridge, he proposed suspending a moving platform for a double line of railway, and making this platform long enough to carry whole trains of cars. The obstruction which this plan offered to shipping was from the river piers only, the space between them being always open except for the occasional passing of the moving platform. To avoid all river obstruction, even that offered by the piers, it was proposed by Morse in 1869 to cross the East River with a single suspension span having a clear opening of 1,410 feet and an under height of 140 feet, travel being conveyed, not over the bridge, but on a moving platform suspended from the upper runway deck. In other respects his design was similar to Houghton's, for it showed no inclined approaches, but merely a suspended platform about 150 feet long to travel back and forth at intervals between New York and Brooklyn. As far as the length of span was concerned, the design was not remarkable, for suspension bridges with lengths of 1,200 feet or more between the towers, had previously been built, and several had been proposed of much greater length,

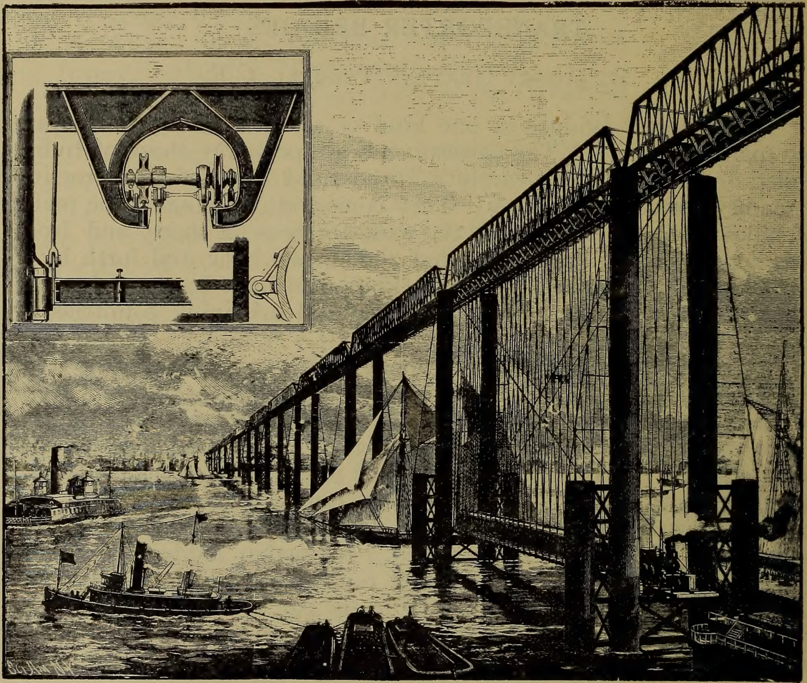

Fig. 1.

including the notable design of M. Oudry, for crossing Messina Straits with four suspension spans of 1,000 meters each.

In 1873, Mr. Charles Smith, manager of the Hartlepool Iron Works, of Hartlepool, England, designed a transporter bridge with cantilever trusses to cross the Tees at Middlesborough, with a center span of 650 feet and a total length of 1,000 feet. His plans were endorsed by no less an authority than Benjamin Baker, but because of insufficient funds, the project was not carried to completion and a steam ferry was installed instead, at a cost of less than $50,000. On account of the publicity given to this project, it has often, but incorrectly, been referred to as the first design for a transporter bridge.

Five years later, an elaborate plan for a transporter bridge over the Thames, was prepared by L. Mills and A. Twyman of North Shields, with a center opening 200 feet in width and 80 feet high. The upper platform, reached by elevators in the towers, was to have provision for pedestrian travel, so that foot passengers could cross at all times.

As transporter bridges are especially suitable for crossing harbor entrances at the sea coast, the type had for many years been advocated for the water sources at New York, and in 1885, Mr. John F. Anderson published a design, Fig. 1, for crossing the Hudson by means of a moving platform suspended from a high level track, supported on pairs of cylinder piers. The platform was to be long enough to always be in contact with three sets of piers, thereby insuring lateral stability. In other respects the design was quite similar to those previously prepared by Harvey Leach and H. N. Houghton, and to Haege's plan for a rolling railway bridge. Two years previous to this (1883), Mr. Gustav Lindenthal had been granted an American patent on a transporter bridge with a traveling suspended car.

During the year 1894, two important passenger cableways were erected, one near Knoxville, Tennessee, and the other at Brighton Dyke, England, the car on the former one moving on a cable with steep incline. The cableway crossing Devil's Dyke at Brighton, designed by W. J. Brewer, had a clear center span of 650 feet, the type being selected because conditions would not permit the expense of a regular bridge. An upper unstiffened cable over the towers, with a sag of only 26 feet, supports all the load, and two lower horizontal cables suspended therefrom by one-inch steel bars, carry the trolley at a height of 230 feet above the valley at the deepest part. The car is only 5 by 7 feet, to hold from eight to twelve passengers, and it is hauled back and forth by a smaller rope, making the passage in 2½ minutes. After its completion, 720 people were taken across and back in 2½ hours.

The development and introduction of transporter bridges is due chiefly to the enterprise of Ferdinand J. Arnodin, proprietor of the iron works at Chateauneuf, France, who during the past twenty years has erected at least eight of these structures at Bilbao, Bizerta, Rouen, Rochefort, Nantes, Marseilles, Newport, and

Tangier. The first of these, between Portugalete and Los Arenas, over the mouth of the Nervion or Bilbao River, on the coast of the Bay of Biscay, about ten miles from Bilbao, Spain, was completed in 1893 (Fig. 2). The metal towers rising at each side of the river are 525 feet apart on center, and a horizontal runway 131 feet above water is supported by cables passing over the towers and anchored to blocks of masonry. The horizontal runway, in addition to hanging from the cables above it, is supported at each end for about one-quarter the span length, by stay cables from the towers. The total moving dead load is 40 tons, and the car which carries 150 passengers, crosses from one side to the other in one minute. The design is the combined work of Arnodin and Palacio.

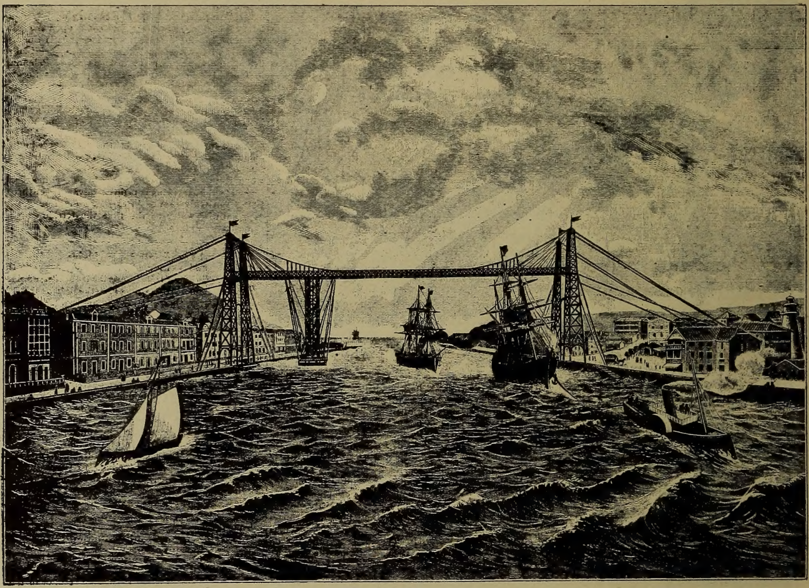

Fig. 2.

The second of M. Arnodin's designs crosses a canal at Bizerta in Tunis, and replaced the ferry which was guided by a cable during transit. The bridge was commenced in 1896 and completed two years later. It is similar in outline to that at Bilbao but with a shorter span, the distance between the towers, which are 213 feet high, being only 355 feet, though the under clearance of 148 feet is slightly greater than the previous one. The car is 32 feet by 24 feet, and it is moved by a steel cable and steam power. The itemized cost was as follows:—

Steel, without machinery	$95,500
Machinery	8,600

Miscellaneous work	2,600
Duty	5,000
	$111,700

It was severely tested by a cyclone in 1898, but remained uninjured. It was proposed by the government in 1904 to take the structure down and to re-erect it at Bordeaux or Brest, changing the motive power from steam to electricity.

The third of M. Arnodin's designs was completed a year later (1899) over the Seine at Rouen, being quite similar to his first one at Bilbao, though with a larger capacity and cost. The clear distance between docks is 436 feet, and between tower centers 469 feet, while the under clearance above the dock is 164 feet. The towers, which are 221 feet high, support twelve steel wire cables from which the horizontal runway is suspended. The moving platform is 33 feet long and 42 feet wide, and has a weight of 37 tons when empty, and 45 tons when loaded. It has a capacity for 200 persons and 6 vehicles, and is suspended from the trolley by thirty cables. The car, Fig. 3, can be made to cross the channel in 45 seconds, though the usual time is about 80 seconds. Its maximum daily service is 240 trips to and fro, carrying 300 vehicles and 10,000 passengers. It cost $180,000 and the schedule of tolls thereon is as follows:—

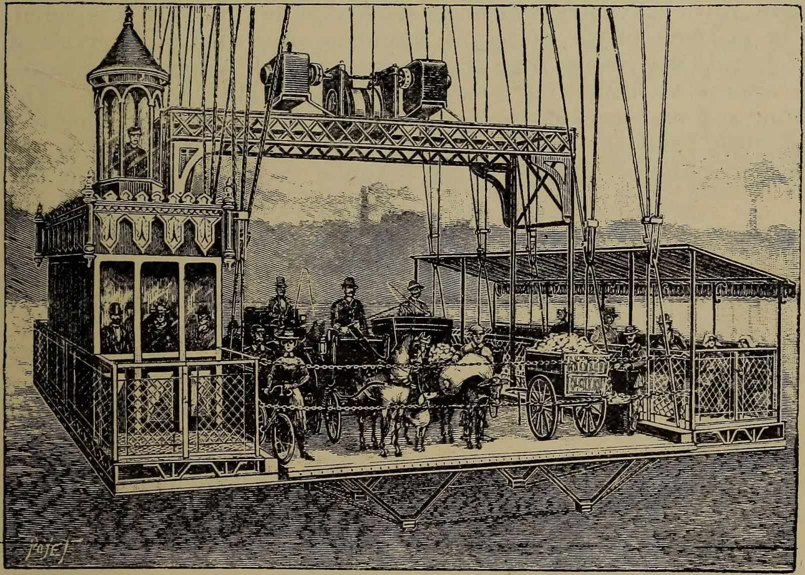

Fig. 3

First-class passengers	2 cents
Second-class passengers	1 cent

Two wheeled rig	6 cents
Four wheeled rig	8 cents
One-horse cart, empty	5 cents
One-horse cart, loaded	8 cents
Two-horse cart, empty	7 cents
Four-horse cart, loaded	13 cents

During the following year (1900), M. Arnodin proposed several transporter bridges in England, one over the Ribble Navigation, and another over the Tyne between North and South Shields, with a span of 650 feet, having the co-operation of Mr. C. H. Gadsby on the latter one. In June, 1901, M. Arnodin took out American patents on a transporter bridge of cantilever type with suspended center span, similar to that which he completed in 1903 over the Loire River at Nantes, which was the first of its kind to be completed. The platform of the bridge at Nantes is supported at intervals of 15 feet by stay cables from the tower tops, and the projecting cantilever arms are connected by a suspended span 113½ feet long. The front and rear arms of the cantilever are 175 and 82 feet long respectively, and the rear end is tied down with wire ropes to the anchor masonry. The distance between the tower centers is 462 feet and the total length 626 feet, the clear height underneath for ships being 165 feet. The trusses are 26 feet apart and the car suspended from them is 40 by 40 feet, with a maximum capacity of 60 tons. It is operated by an electric motor on the truck, and will cross the water in one minute. It cost $199,000, and the schedule of charges is as follows:—

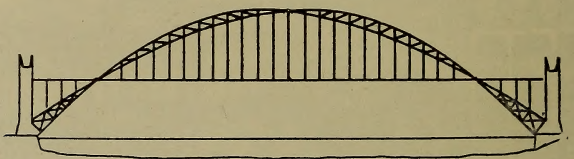

Fig. 4

Pedestrians	1 cent each
One-horse cart, empty	5 cents each
Two-horse cart, empty	7 cents each
One-horse cart, loaded	8 cents each
Two-horse cart, loaded	10 cents each
Wagons, loaded	12 cents each

The most daring project for a transporter bridge ever undertaken was that which appeared in 1903 for crossing the Gironde River at Bordeaux, with a single arch of 1,412 feet (Fig. 4) the span being about the same as that designed by Morse in 1869 for crossing the East River at New York. The proposed Bordeaux bridge consisted of a pair of metal arches, in vertical planes and about 80 feet apart, from which the runway deck was suspended, leaving a clearance of

150 feet beneath it. The total rise of the arch was 328 feet (100 meters) and that part of the ribs above the runway were lune-shaped with three hinges, the longitudinal distance between the end pins being shortened by this arrangement to 990 feet, similar to that used about the same time for the Austerlitz arch bridge at Paris. The clear distance between docks was to be 1,312 feet, and that between towers centres 100 feet additional, making it longer than any arch yet built. The runaway deck had provision for a footwalk but was without stiffening trusses, and it supported a double line of track, so that cars might start from each side of the river at the same time. Towers were 33 by 112 feet, and 164 feet high and they had elevators to carry passengers to the upper crossing. A somewhat similar bridge, though not a transporter, was proposed by Max Ende for crossing the Thames at London. In the last case, instead of using suspended cars, travel of all kinds was to be raised and lowered on elevators running on inclined tracks at the ends, and descending into pits below the streets at each side of the river. (See Tyrrell's *History of Bridge Engineering*, page 336.)

The Marseilles transporter of 1904 is similar to that at Nantes, with cantilever arms and a centre span. Towers stand on cylinders and are 541 feet apart on centre, and the runway deck which was erected by cantilever method, is 160 feet above the water.

Up to this time, transporter bridges had not been used in America. though they are quite as suitable for harbor entrances here, as in Europe, but in 1905, the first and only one on this side of the Atlantic, was completed, over the ship canal from Lake Avenue, Duluth, to Minnesota Point. The site had been a perplexing one for bridge engineers, for they had wrestled with the problem for fifteen years or more. In 1890, Mr. A. P. Boller made plans for a swing bridge revolving horizontally on a shore pier, with a clear opening of 200 feet and deck 20 feet above water, the estimated cost being $400,000. As this was more than the city cared to spend, a prize of $1,000 was offered for the best design for a movable bridge to suit the place, and in response, twenty or more plans were prepared and submitted. Estimates were also submitted for a double tunnel, varying in amount from $500,000 to $1,300,000. In 1899, when the bridge at Rouen had been completed and publicly illustrated, the city engineer, Mr. T. F. McGilvray, prepared drawings for a similar bridge to cross the channel at Duluth with a clear opening of 300 feet, or 383 feet between tower centres. French engineers having discovered the lack of rigidity in suspended tracks for short span transporter bridges, were planning a new one for Nantes on the cantilever principle with an intermediate truss, similar in some respects to that proposed by Charles Smith in 1873 for Middlesborough. An alternate plan to that prepared by the Duluth city engineer, was also made in 1901 by a local agent of the American Bridge Company that was tendering for a construction contract. In this plan (Fig. 5) rigid framing was used throughout, the distance between front tower legs being 393 feet, 9 inches, and the height beneath the bridge 135 feet, as at New York City. As the structure from its exposed position would certainly

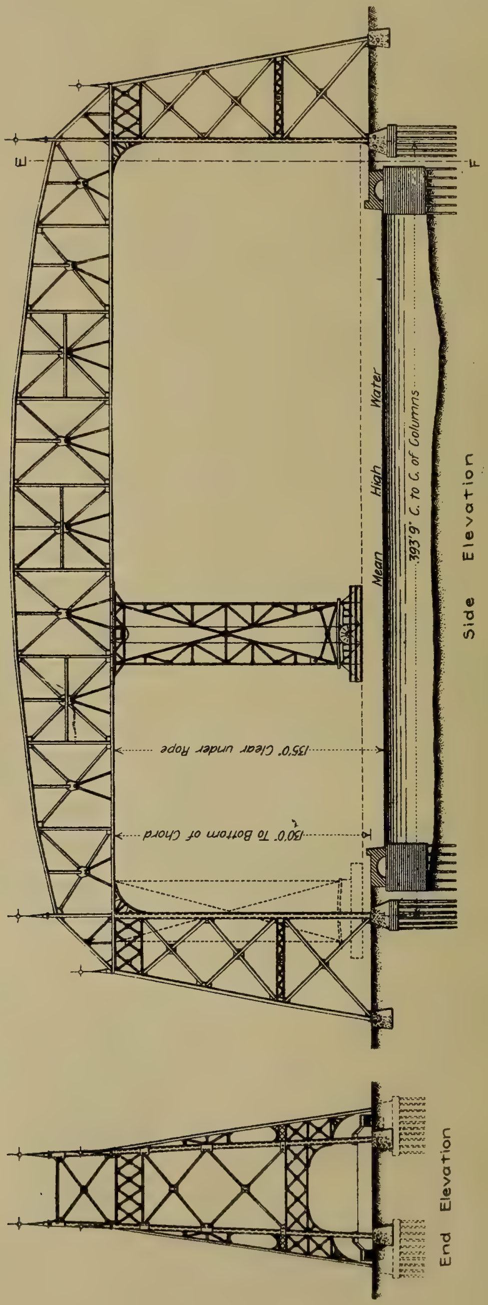
E
F
Mean High Water
393'9" C. to C. of Columns
135'0" Clear under Rope
130'0" To Bottom of Chord
Side Elevation
End Elevation

Fig. 5

be subject to severe gales, every effort was made to secure rigidity, double riveted web systems being used in the trusses and stiff braced members for the car suspenders, thus preventing it from swaying in the wind. Several types of construction had previously been used for transporter bridges in Europe, those at Bilbao, Bizerta, and Rouen, being suspensions; Nantes and Marseilles, cantilevers; and the proposed one at Bordeaux an arch; and it is interesting to note that still another type—a simple truss—was selected for the bridge at Duluth, to which, with its comparatively short span, it is well adapted, at the same time making a patent more easily obtainable. In several European designs, the moving car passes through the towers which are braced laterally to resist wind pressure, but in the Duluth bridge the platform runs in between the front columns only, without interfering with the tower bracing on the outer side. The car is suspended from a rigid trolley frame, the wheels of which, mounted on roller bearings, run on rails inside the box chords. The car is propelled by electric power from two different scoures, a one-inch steel rope being fastened to each tower and wound on a drum attached to the moving part. When moved by electric power, the car crosses the canal in one minute, but it also has hand power for emergency. Both trolley and car run against air buffers at each end, and jar is further avoided by links in the suspenders near the deck. Construction was under way more or less for four years and after much delay, change of contractors, and revision of plans, it was finally completed in 1905 at a cost of $100,000, though a number of ornamental features that were at first intended were omitted.

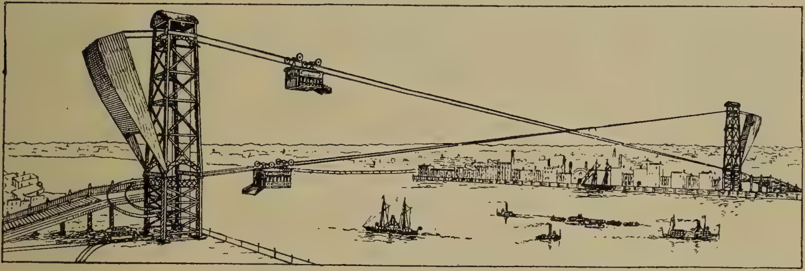

Fig. 6

Another very interesting design for a modified type of transporter bridge appeared in 1905, the invention of Abraham Abelson of New York, the essential principle of which was gravity car motion. As will be seen from the illustration (Fig. 6) at each side of the river or ravine, towers are erected, to the base of which double cables are attached, which, after crossing to the opposite side, pass over saddles at the tower tops and fasten to counterweights hinged to the opposite side. This method of fastening the cables avoids the obstruction caused by carrying them back in the usual way to anchor blocks on shore, and at the same time holds the cables taut though not absolutely rigid. The same anchorage principle is now applied in modern freight cableways and is effective in allowing for expansion or slight variation in the cable length. The effect of the hinged weights counteracting the pull on the cables is to produce vertical reactions on the towers, without any tendency to tipping. An elevator operates in each tower, and a car on crossing from the other side makes a detour around the tower to the land side and is then loaded on the elevator by which it is lifted to the upper level. The car trucks are swiveled that they may be easily removed from contact with the cables and attached to them again in their raised position. The cars are not connected with each other and their speed may be regulated by the operator.

Although transporter bridges have been projected in Great Britain for forty years or more, none were built there prior to 1905, but since that time four fine structures have been completed at Runcorn, Newport, Warrington and Middlesborough, three of which were the designs of English engineers. A suspension over the Mersey at Runcorn was proposed in 1817 by Thomas Telford though never built. His design showed a clear span of 1,000 feet with stone towers, a roadway 30 feet wide, and a clearance of 70 feet above the water, the estimated cost being $450,000. But the river at that place remained unbridged until 1868, when the London and North Western Railway erected a bridge 1,300 feet long in three spans, with an under clearance of 78 feet, to the deck of which pedestrians had access by stairs at the ends. The new suspension transporter crosses the Mersey and the Manchester Ship Canal between Widnes and Runcorn with a span of 1,000 feet, and an under clearance of 82 feet, or slightly more than that at the railway bridge near by, and it is now the longest highway span in Great Britain. It consists of a stiffened track, hung from cables passing over metal towers on shore, high enough to permit ships to pass under, the cables being anchored back into blocks of masonry. The two main cables are 12 inches in diameter and are cradled according to the method first used by John A. Roebling in 1844. Each cable is composed of nineteen smaller ones, and the whole is wrapped and protected from the weather by canvas and bitumen. The angle of inclination which the cable makes with the vertical is different at each side of the tower, and the stress in the back stays is, therefore, about 12 per cent. greater than in the span. Where they bear on the saddles at the tower tops, the cables and saddles are clamped together to prevent slipping and to insure vertical reactions. The cables at the ends are attached to bars or links which are anchored into blocks of masonry, the bars being embedded solid in concrete after receiving the stress from dead load. The double towers on each shore are gracefully proportioned tapering out towards the base like the trunks of great trees, and they are connected by ornamental portals and diagonal bracing. Each one is composed of four columns forming a rectangle 30 feet square at the base, the transverse distance between tower centres being 70 feet. A stair at each end gives access for pedestrians to the elevated foot walk. Under each tower leg is a cast iron cylinder 9 feet in diameter with 1 1-8 inch metal, the interior of the cylinders being filled solid with concrete. The stiffening girders are 18 feet deep and 35 feet apart, the two halves being connected at the centre by hinges. The moving platform or car is 24 feet wide and 55 feet long, with a single road and a covered space for pedestrians at one side. It weighs 120 tons and the usual time for crossing is 1¾ minutes, the moving being controlled by a man in an elevated cabin on the car above the roadway. The car is suspended from a trolley 77 feet long, mounted on wheels 18 inches diameter, and running on the track of the elevated deck. It is propelled by an electric motor on the trolley which is supplied with power from a generating station near by. The engineers were J. J. Webster and J. T. Wood, and the contractor, Sir William Arrol & Co., the total cost including approaches being $665,000. It was formally opened in May, 1905.

A bridge over the Usk at Newport in South Wales, designed by F. J. Arnodin and R. H. Haynes was under construction at the same time as the last one described, but though sanctioned by Parliament in 1900, work was not completed until 1906. A stone bridge in five spans was placed over the river in 1800, and it was repaired and widened in 1866 and 1882, and yet another bridge or better crossing facilities were needed. Preliminary designs and estimates for bridges of different sorts showed that a high level structure would cost $6,250,000, and a low level bridge with a swing span, about $3,500,000, the cost in both cases being much greater than the authorities cared to pay. The design for a transporter bridge which was accepted is of the suspension type, with a length of 645 feet between tower centres, and 592 feet in the clear, the distance between centre of anchorages being 1545 feet. The headroom above the water is 177 feet, and the design in general is somewhat similar to Arnodin's other suspensions. Towers are pin-ended and their tops are 242 feet above the approaches and 269 feet above low water. Each tower contains 277 tons of steel, and stands on four cylinder piers. Sixteen smaller cables were used instead of a single large one at each side, as on the bridge at Runcorn, conforming with the usual French custom. The traveler which is mounted on sixty cast steel wheels, is 104 feet long and 26 feet wide, and from it is suspended the moving car, 33 feet long and 40 feet wide, weighing 51 tons. It is capable of carrying a live load of 66 tons and its maximum rate of travel is 10 feet per second, being propelled by wire rope and electric power. The cost in detail was as follows:—

Foundations	$95,600
Shore abutments	18,400
Superstructure	140,000
	$254,000

The third bridge of the kind in England crosses the Mersey at Warrington, 18 miles from the larger one at Runcorn. It was erected chiefly for the convenience of employees at the manufactury of Joseph Crosfield & Son on a strip of land known as Tongueland, between adjoining bends in the river. It is of suspension type and has a span between towers of only 250 feet, with an under clearance of 75 feet as required by government. Stiffening trusses are without hinges and were proportioned according to the theory of Merriman and Jacoby. Single cables 7 inches in diameter of plough steel wire were used at each side, the economical sag for the specified load being found by trial to be one-twelfth of the span. The horizontal track is suspended from the cables by 1¼-inch rods, 10 feet apart, and from this track the car, which has a capacity of only 5,000 pounds, is hung. The accepted design was submitted by Thomas Piggott & Co., of Birmingham, the resident engineer on the work being James Newall.

The transporter bridge over the Tees between Middlesborough and Port Clarence, forming a connection between North Yorkshire and Durham County, though proposed in 1873, and elaborate plans then prepared, was the last of four in England to be erected, for it was not formally opened until October, 1911, after twenty-seven months of actual construction. It consists of double cantilevers on metal towers anchored at the rear ends to blocks of masonry, and in many respects is similar to the design previously made for the same site by Charles Smith of Hartlepool. The span between centre of towers which are 225 feet high, is 570 feet, and the total length is 850 feet. An elevated foot walk over the bridge is reached by stairs in the towers. The moving car is 41 by 39 feet, with space of six carriages and 600 persons, and it is moved by an endless rope. It contains 2,600 tons of steel with 600 tons in the foundation, and the total cost was $408,000. It was designed by the Cleveland Bridge and Engineering Co., and built by Sir William Arrol & Co. Another bridge of suspension type with pin-ended towers 390 feet apart on centres, was erected at the Kiel Dockyard in 1911.

From the above brief descriptions, it appears that transporter or ferry bridges have a definite use, and are especially applicable for harbor entrances on the sea coast or at other exposed positions, where ships which are unfamiliar with local drawbridge signals, are frequently entering, or where they may be driven for safety during storms. To shipping, they offer nearly all the advantages of a high level fixed bridge, and still permit land travel to cross at about water level, at the same time saving the expense of inclined approaches to a high level structure.

Illustrations are from Tyrrell's *History of Bridge Engineering*, *Engineering News*, and *The Scientific American.*

D. L. H. Forbes, '02, has been appointed consulting engineer for the Trethewey Mine, at Cobalt. Mr. Forbes' office is located in the Manning Chambers, Toronto. S. M. Thorne, '00, is his assistant at the Trethewey mine.

F. A. Gaby, B.A.Sc., '03, has been appointed chief engineer of the Ontario Hydro-Electric Power Commission, succeeding Mr. P. W. Sothmann, who has occupied that position during the last six years.

STEEL RAIL FAILURES

By H. Hyatt, B.A.Sc.

PART II.

The June issue contained the first part of this article dealing briefly with the evolution of the steel rail as used to-day, and to some length with the design of its cross sections, the first of a classification into four groups into one of which, or a combination of two or more, the causes producing failure are likely to fall. This article continues a study of these causes by considering the remaining three divisions of the classification, and concludes with a summary of remedies that have been adopted and are now in use as a deterrent to the many accidents attributed to rail fractures.

Chemical Composition of the Steel

The chief constituents of rail steel which are liable, or said to be liable, when present in excessive or inadequate quantities, to cause the failure of rails when in service, are carbon, phosphorus, and sulphur. Besides these the other common constituents are silicon and manganese. Still further, there are a number of substances, such as nickel, vanadium, manganese, titanium, etc., which are employed to form alloy steels, and these alloy steels are coming into use in the manufacture of rails, though none of them are common as yet, nor have they been in use any great length of time, and data as to actual results are consequently very meagre.

As is well known a high carbon steel is a hard steel which will resist wear, but if carbon be present in rail steel in too great a quantity the rails are brittle and liable to fail when put in track. On the other hand, too small a percentage of carbon gives a steel which is too soft to resist either abrasion by the wheel treads or crushing by the wheel loads. Another difficulty with high carbon is that the higher the carbon the greater is the liability of its becoming segregated. As is also well known, an excess of phosphorus will likewise produce brittleness. With regard to sulphur a definite statement cannot be made. Sulphur is entirely omitted in some specifications since it is taken for granted that it will be reduced to a minimum by the manufacturer on his own account because a high sulphur steel, where the sulphur is in the form of iron sulphide, can be rolled only with difficulty if at all. There are, however, some who believe that that small percentage of sulphur which remains in the finished rail is, particularly in the form of manganese sulphide, a prime factor in a great number of failures.

Another portion of the discussion which belongs under this section is the often heard proposition that all rail steel be manufactured by the Open Hearth Process in place of the Bessemer. This is due to the fact that the Bessemer process cannot be used to reduce the percentage of phosphorus in an ore while the good Bessemer low phosphorus ores on this continent are becoming worked out. While chiefly on a more or less experimental basis there have nevertheless been a considerable number of open hearth rails manufactured, but it is still too early to say whether the experiments have been altogether successful or not. The fact remains that rails are for much the greater part still being made by the Bessemer process, not only on account of its being less expensive, but also because there are not a sufficient number of open hearth mills to supply the demand for all the rails that are required, and hence in considering rail failures the Bessemer process must be taken into account.

The combination of carbon and phosphorus in rail steel is another important point, but the exact proportions of each that are advisable is evidently a matter of doubt. For instance, the Rail Committee of the American Railway Engineering and Maintenance of Way Association report in 1910 that, "We believe it necessary to submit a sliding scale for the percentages of carbon and phosphorus, which provides for increasing the carbon as the phosphorus decreases. The American Railway Association specification calls attention to the matter in the following words: 'When lower phosphorus can be secured, a proper proportionate increase in carbon should be made.' The amount of increase is not provided for in the specifications, and this appears to us to be necessary in order to secure uniformity of practice; otherwise the fixing of these percentages becomes a matter of special arrangement. Bessemer rails are being furnished regularly with phosphorus under the maximum allowed, and when this is done, the carbon should be raised above the higher limit now fixed in our specifications, or a soft and poor wearing rail will result; yet this condition has not been fully guarded against in rails furnished under existing specifications. The lower and upper limits for carbon have heretofore been fixed with the intention that the mills furnish rails with a composition as near between the two limits as possible. The mills, however, in order to meet the prescribed tests with the least difficulty, keep both carbon and manganese as nearly as possible to the lower limits, with the corresponding result that a generally poor-wearing rail is furnished."

With regard to the same question, Benjamin Talbot writes as follows: "The treacherous nature of steel, high in carbon, manganese, and phosphorus, is well known. Any increase in the carbon accentuates this danger. A point, however, which has not been so well dwelt upon is whether high carbon steel, even though low in phosphorus, is not in some cases dangerous, due to the fact that segregation will take place, sometimes to a very marked amount. The Pennsylvania Railroad has specified that open hearth rails must have 0.8 to 0.9 per cent. carbon for 90 to 100 pound rails with 0.03 per cent. phosphorus. Undoubtedly this steel should form a very excellent material for rail purposes if it could be guaranteed that no segregation of the carbon would take place whereby one part of the rail might become still higher in carbon and so cause the material to become brittle. It will be of interest to learn how such high carbon rails behave in practice, and especially how they stand shock under low temperatures. Possible rails with 0.75 per cent. carbon, 0.03

per cent. phosphorus and manganese not above 0.7 per cent. will give the best results."

Also on the same question we quote P. H. Dudley: "The actual wear of the 80 and 100 pound rails which I made at Scranton, with 0.60 to 0.65 per cent. carbon and phosphorus 0.006 per cent., after twelve to fifteen years service only show a loss of metal from the top of the head of from 3-32 to 1-8 of an inch. This is a slow rate of wear, and for 100 and 80 pound rails, is a much better result than can be obtained with metal having 0.10 per cent. phosphorus. The wear in that class of metal is from three to four times greater than it was with the high carbon and low phosphorus."

With regard to manganese sulphide as a source of failure, Professor Fay of the Massachusetts Institute of Technology, has written that, "Sulphide when present as manganese sulphide has been declared to be harmless, but that it is an extremely brittle and perhaps dangerous material will be demonstrated. It must be stated at once that all manganese sulphide is not injurious, in fact most of it is harmless. The conditions under which it becomes harmful will be shown." Professor Fay then proceeds with a discussion of a number of breaks and calls attention to an almost invariable presence of manganese sulphide at the origin of fracture. It is a brittle substance in which fracture may begin and whence it may continue into the steel itself. The manganese sulphide is found in rails in elongated threads. This is explained by the demonstrated fact that manganese sulphide has a freezing point of 1162°C., whereas rail steel solidifies at about 1450°C. If rolling begins at any temperature above 1162°C., the manganese sulphide will be liquid from the temperature at which rolling began until it falls to 1162°C, and below this temperature, being in a plastic condition, it is elongated in the direction of rolling. Where rolling pressure is exerted on three sides, as in rails, it would appear as elongated threads. The author concludes from this that it is not to be doubted that manganese sulphide when existing in certain forms is a harmful constituent of steels, and continues with regard to remedies as follows: "Steels which are high in sulphur should not be rolled at too high a temperature, for if manganese sulphide is entrapped it will surely be rolled out into a form which will ultimately lead to trouble, but specifications should be so drawn as to limit the amount of sulphur in the steel. At the present time most of the specifications do not even mention sulphur. The next step is to allow the metal to stand a longer time after the addition of the ferro-manganese. With the specific gravity of manganese sulphide at 3.966 and that of steel at 6.82, it should rise to the surface and be skimmed off with the slag if given sufficient time. Usually this time interval, between the charging of the ferro-manganese and the pouring of the ingot, is very short. The desire of the manufacturer to increase his output has led him to cut down the interval to the shortest possible limit with the natural consequence of a large number of broken rails. A longer time interval will allow the metal to purify itself. If, on the other hand, it is not permissible to start with a low sulphur ore, or a sufficient time interval for the removal of the manganese-sulphide, resort must be had to electric refining of the molten metal by means of a basic slag."[1]

Concerning alloy steels, or steels containing a high percentage of various materials introduced to give the steel some special mechanical qualities, something should also be said, since it is probable that the more general use of such steels in the manufacture of rails would have a decided influence on rail failures. Some of the alloys best known at the present time are manganese, nickel and chromium. Manganese in particular is being employed in the manufacture of frogs. Those alloys fast coming into use among employers of steel, but which are rarer than the three first mentioned, are tungsten, molybdenum, vanadium, uranium and titanium. The actual effect of these alloys is not well understood even by expert metallurgists, but there is not much doubt but that they add valuable qualities to the steel.

The alloy which is particularly considered as a valuable one in connection with rails, it titanium. For instance, A. W. Thompson, Chief Engineer of the Baltimore and Ohio, says that titanium has been used by his road, and that its use has resulted in a rail with a composition high in carbon and phosphorus, but which even then successfully passed the physical test. Tests in the track are, however, too immature as yet for consideration. G. B. Waterhouse also makes reference to the same subject, and says that titanium when rightly applied in the proper amount is found to retard segregation of sulphur, phosphorus, and carbon in what is normally quiet quick-setting steel. And, referring to the contention of some for an increase in the discard, is of the opinion that in all commercial steels the bulk of the ingot must be used, and hence he believes the experimental results obtained with the use of titanium to be of importance, showing as they do, one way in which segregation may be considerably controlled.

Manufacture of the Steel and Rolling of the Rail.

When it is considered that the loads which the rail has to carry are not excessive, and that the supports upon which the rail rests are ample, it logically follows that if the rail fails it must be composed of defective steel, also that defective steel is the result of faults in the manufacturing process. This is the position taken by the greater number of railroad engineers and officials with regard to the failure of rails during their service in track. On the other hand, those engaged in the manufacture of the rails take the position that the premises stated above will not hold, that the loads which the rail has to carry are excessive, and that the supports carrying the rail are not sufficient. There are points that can be offered in favor of both sides of the question, In this section it is proposed to state in a very general way the chief criticisms that have been made with regard to the many details of steel manufacturing as either sole or contributory factors of the abnormal number of rail failures which have occurred and which are occurring.

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[1] Henry Fay, Proc. A.S.T.M., Vol. 8, pp. 74.

Since the time when the manufacture of steel rails was first established on a commercial basis, there has been a continual endeavor on the part of the manufacturers to turn out the product in the shortest possible space of time. This endeavor has been eminently successful, provided that the quality of the steel rails has at the same time been maintained. But this, according to many authorities, is where much, if not the greater part of the trouble with rails has originated. They claim that the time of manufacturing has been cut down to such a small period, that, with the methods in vogue, it is impossible for good, sound, homogeneous steel to be the product. They claim that an insufficient time is allowed for the chemical reactions to be properly completed; that the working and rolling of the steel is done too rapidly; and that, in endeavoring to still further cut down the time, the reductions per pass are made too heavy; that the passes are too few in number, and that the process of rolling is carried on with the steel at too high a temperature; not to mention other items which go toward completing a formidable list. All such practices tend toward the final production of rails composed of poor steel, and poor steel in turn tends towards failure.

The manufacture of steel is a chemical process and every chemical process requires time if the reactions are to be complete. Hence, if a good steel ingot is required time must be taken between the pouring of the steel into the ladle and the teeming of the steel into the ingot mould, in order to allow thorough chemical reactions, the entire escape of the gases, and the separation of the slag. Unless such time is allowed before teeming is commenced, the reactions but partially complete themselves in the setting steel of the ingot, and the slag oxides and the gases are often entrained instead of eliminated. The minute globules or particles of slag from the reactions caught in the columnar structure, also in the secondary zone of blow holes, with or without associated oxides, are important factors in the checking of the tender skin of the ingots in blooming, and the subsequent tearing of the flanges as their extreme edges must slip in the passes of the rolls. The slag and occluded gases in connection with segregated metal are important factors in the split heads of rails, which develop between the ends after a short or a long period of service, depending upon the thickness of the metal in the bearing surface over the entrained slag and occluded gases.

Too rapid rolling of the steel rail has bad results in two directions. In the first place, if the reductions per pass be too great the steel is torn, instead of being simply squeezed or compressed, with the result that large cracks are developed in the steel, and there is no subsequent operation of the rolling process that will weld these cracks up. The cracks are elongated and may apparently disappear, but the defects are still there, and I believe that many a subsequent mysterious failure of rails made from such ingots, if we could trace it back, would be accounted for by the cracks developed in the blooming rolls. Secondly, the short time during which the rail undergoes rolling results in a steel which is not sufficiently worked, and hence a steel is produced of a coarse granular structure. The rails made to the larger sections necessarily receive less work than did those made to the smaller, and in addition to this, the diameter of the rolls has been increased, the power of the engines driving them has been increased, and the number of passes used in rolling the rails has been decreased. Each of these items tends towards a decrease in the working which the steel receives, and therefore, towards steel of a poorer quality.

The rolling of the steel when it is at a high temperature makes the rolling more easy, and the time of shorter duration, but the consequence is that rolling comes to an end with the steel still at a temperature far above the critical, and hence this is another practice which tends towards the production of low quality steel. The later specifications guard against this by stipulating that the finishing temperature shall be such that the shrinkage after leaving the hot saws shall not exceed a certain specified number of inches. In order to comply with this specification it is said that some mills have held the rails before the last pass while the temperature fell, and this, of course, is a practice which is just as detrimental to the finished rail as the first.

The reduction of the time taken for the manufacturing process has thus led to a number of bad effects in the finished rail; general unsoundness due to the incompletion of chemical reactions; the entraining in the steel of slag particles, manganese sulphite, blow holes, etc., causing defects in the final product; and coarseness of structure and additional unsoundness due both to decreases in the amount of work done on the steel and also to the high temperature at which rolling occurs.

Another detail of the manufacturing process, about which much discussion has taken place with regard to its bearing on rail failures, is the quantity that should be discarded from each ingot in order to eliminate what is generally recognized as the poorer portion—that portion in which segregation and piping are most likely to occur. The discard of a large percentage of the ingot is an expensive item and the percentage is therefore kept down as low as is possible, but some roads have found it advisable to specify a crop of as much as 30 per cent. For instance, the Baltimore and Ohio some six years ago decided to increase the crop from 5 to 30 per cent. and by so doing increased the removal of rails from the track, on account of split heads during the first year of their service, from 22 to 1.75 per cent. On the other hand we read that of all the rails put in track by the Pennsylvania Railroad only about 1-40 of one per cent. failed in any one year. Assuming the average life at eight years this would be 1-5 of one per cent., so that in discarding 25 per cent. we would be discarding 24 and 4-5 per cent. of metal for the sake of eliminating 1-5 of one per cent. It may be stated further that a specification making such a waste unnecessary is one which calls for the testing to destruction of the crop end of every ingot, and, if piping is shown, all the top rails from the heat are to be rejected. This gives about a 30-per cent. discard from all heats which show piping, while those which do not show piping are cropped but a small amount.

The specifying of a certain large percentage crop from all ingots, while it seems to secure the necessary results, is nevertheless a wasteful expedient to employ for every heat of rail steel, and that specification is the best which leaves the discard to the manufacturer and safeguards the product by proper tests. If the test piece is chosen from such a location, and if the rejections made according to the test are sufficiently severe that it will be to the interest of the manufacturer to discard all poor metal on his own account, the object in view will be attained, and in addition to this it will stimulate the use of better manufacturing methods which will reduce piping and segregation to a minimum.

Still another detail which is discussed with regard to its bearing on the production of sound rail steel is the size of the ingot. There are those who consider that the size of the ingot should be reduced since a large ingot necessarily leads to increased segregation, which is, it gives areas of metal which contain large percentages of phosphorus or carbon, a decided factor of the general conditions leading to failure. On the other hand, there are others who advocate an increase in the size of the ingot in order to obtain the same amount of working for the steel during its reduction in the rolls as was given to the smaller rails. If the ingot remains of the same size while the rails increase in weight it follows that the work put into the steel is not so great, and hence larger ingots are necessary. But the larger the ingot the greater is the proportion of segregation and piping. There are thus arguments to be advanced in favor of both increase and decrease, and a mean must be sought unless segregation and piping can be reduced by other means.

These are the most important parts of the manufacturing process that have been discussed as factors in the rail failure problem. In addition there are a large number of other details, such as the production of low carbon areas due to the introduction of foreign substances in the ingot moulds to prevent trouble with the stools, and failures originating in fractures made during the process of gagging.

As in considering the chemical composition of the steel, so in considering the manufacturing process in general, the open hearth process is often mentioned as the remedy for a great proportion of the trouble that is found in connection with the Bessemer process. But for the most part the same precautions must be observed in manufacturing steel by the one process as by the other, and there is considerable doubt as to whether the open hearth rail would prove to be of any better quality than the Bessemer. If time and money be employed in the future, as they have been employed in the past over the commercial development of the Bessemer process, in getting sound ingots, free from blow holes, slag, manganese sulphide, segregation and piping, the Bessemer process should prove to be more economical, in the true sense of the word, than the open hearth for the production of steel for rail purposes.

Roadbed Conditions and Effect of the Rolling Stock

Given a rail of the proper section and composed of good steel, failure may still occur by reason of the rail being placed in a bad piece of track or on account of defects in the rolling stock. In any track the rail acts as a girder and is designed in order that it may do the greatest part of the work of distributing the wheel loads to the roadbed. The design is governed by the static wheel loads increased by an impact allowance, by the character of the support the rail is expected to receive, and by a certain factor of safety which is expected to cover any extra stress occasioned by the severe service to which the rail is put. If the support which the rail receives is such or if the rolling stock produces stresses such that the extra material provided to resist everything beyond the static loading is not sufficient, then the elastic limit of the steel will be exceeded and the rail will fail. It is essential, then, that the roadbed be kept in such condition that the support received by the rail is at least as rigid as was expected by the designer, and that certain defects in the rolling stock, which produce greater stresses in the rail than are necessary, be eliminated.

The consideration of the proper support of the rails involves a great part of the whole question of maintenance of way—a question which cannot be properly discussed here. The principal points can, however, be pointed out.

Not considering the factor of safety, rails are designed with the understanding that they shall present a smooth surface to the passage of traffic, and if the track is not properly graded, the impact effect of the load-carrying wheels on the rails will be greater than that for which allowance was made. The ties must be properly tamped, and must present a wide smooth face to the base of the rail, in order that the immediate support of the rail may be sufficient. Owing to the diminishing supply of timber the face of the tie is becoming narrower--a condition which increases the strain in the rail--and it is a possibility that even at the present time this extra strain is one of the elements of the rail failure problem. The joint material contributes towards the support of the rail, but rail failures are but very rarely attributed to imperfect joints. The ballast must be maintained of a proper thickness in order that it may hold the ties in place, distribute the loads evenly to the subgrade, and keep water from the immediate vicinity of the ties.

That portion of the roadbed, which, by its failure to give a sufficiently rigid support to the rail, causes more rail failures than any other portion, is the subgrade. The same rail, with traffic of the same intensity and volume, will have far less failures if the subgrade is sandy, porous, and free from water than if the subgrade is dense, water-soaked clay. The problem in this connection consists in eliminating water from the roadbed—an elimination that cannot be too thoroughly made if rail failures are to be avoided.

Among those defects in the rolling stock which cause rail failures may be mentioned the imperfect counter-balancing of locomotives, and flat spots on wheels—particularly on the driving wheels of locomotives but also on the wheels of cars. Both imperfect counterbalancing and flat spots on wheels are known to have caused quite a number of rail failures, but, at the same time, both causes are in greater part removable by proper precautions being taken in the car repairing shops and the failures arising from such causes are comparatively few in number.

Other causes of rail failure, which have their origin after the rail is put in track, and to which reference may be made in this connection, are, first, brittleness of the rolling surface due to its toughness having been exhausted by the cold flow caused by wheel pressures, second, burning and crystallization of the rail metal due to the slipping of locomotive drivers, and third, the stresses due to those changes of temperature, which occur while the rail is in track.

With the exception of soft and water-bearing subgrades the causes mentioned in this section are of a secondary nature.

Conclusion

Definite conclusions with regard to the problem presented by the frequent fractures of steel rails in service cannot be drawn from a reading of the available literature on the subject. A complete determination of the problem, from which conclusions may be drawn, can be made only by one having a large and varied practical experience in track work, in steel mill methods, and in the processes of examining and testing steel, together with the collection and arrangement of innumerable data. There are, however, several outstanding features of the problem which may be noted to advantage.

First, there is an evident necessity for some change to be made in the rail cross-section in order to do away with the difficulty at present experienced in the process of rolling the heavy sections, due to the large mass of metal in the head carrying the heat so much longer than the thin metal in the web and flanges. A remedy is to increase the weight of the rail by making both flange and web of a greater thickness. Second, the advantage to be gained by counteracting the effects produced by the high phosphorus usually present in the Bessemer rail. Third, the necessity of exercising more care in the manufacture of the steel and in the rolling of the rail. Such a precaution will require the expense of a greater length of time than is now spent in the making of a rail, but there seems to be but little if any doubt that such expenditure, if it be made judiciously in giving more time for the complete reaction of the various chemical processes involved, and in subjecting the rail to a more gradual and complete working during the process of rolling, will prove to be of the greatest advantage when a perfectly satisfactory rail is the desired product. Fourth, the advisability of providing a good, sound, porous, and well-drained subgrade throughout every mile of main line track.

It will be noticed that, as is usually the case, the improvement of the rail in any way calls for additional expense, and there are two ways in which this additional expense may be met—either by a reduction of the profits of the steel manufacturer or by the payment of an increased price by the railroads. Which method of the two is the just one we do not know, but, with the exception of accidents, it would appear as if the entire responsibility for the use of defective rails in track rested with the railroads. If, as some claim, they are unable to obtain satisfactory rails from their manufacturer, they must obtain their rails elsewhere, but in any case they must obtain satisfactory rails even though an increased price must be paid. It is not as if a rail is worth so many dollars, and, if it be broken, so many dollars have been wasted. The railroads are responsible for the safe transportation of passengers and property, and the acceptance of such responsibility necessitates the use of sound rails.

ELECTRIC TRACTION AND ITS PROGRESS

By R. V. Macauley, B.A.Sc.

The steam railway operator no longer regards electric traction as unworthy of his notice, nor considers as mere effusions the claims advanced in support of electric operation as a practical solution of many of the grave problems that confront him in the course of modern heavy transportation. In fact, of late, railroad men have begun to take a very live interest in electrification, as is evident from the importance accorded to electric traction discussion by the various railway congresses and railroad engineering clubs. This change of heart has resulted from the more rational appreciation of heavy railroad problems by the electrical engineer, and, also, from the actual demonstration of the efficacy of electric traction under different trunk line conditions.

The subject of railroad electrification is a very broad one, embracing a great variety of engineering and other problems. The magnitude of the question is almost startling—it having been estimated that to take care of the heavy railway business of the United States for the year 1907 by means of electric locomotives, would require 24,000 locomotives worth $25,000 each, or an aggregate cost for electric locomotives alone of $600,000,000. It is thus evident that in such an article as this the limitations of time and space allow but a very limited treatment ot certain phases of the general problem.

Trunk line railroad electrification necessarily refers largely to the conversion of existing steam-operated railroads into electric-operated roads; but it is important to note that in many cases new electric lines are operating under substantially the same conditions of traffic as obtain on many steam lines. At present many interurban and cross-country trolley lines are invading the field of the steam railway, and some of these lines have developed into quite extensive systems, operating over private right-of-way, and approximating in distances and speeds the conditions of steam railroads, but differing from steam railways in the elaboration of provisions for train-handling, in equipment of line with stations, yards, signals, etc., and in the organization for conducting a general transportation business, local and foreign, in both passengers and commodities.

"Trunk lines" are understood to be "lines between large cities, having important terminals and a mixture of light and heavy passenger and freight traffic."

The discussion here will be found to refer wholly to American practice, there being but one or two remarks on European practice. The aspects of trunk line electrification, which are discussed, consist of the following: The history and status of electric traction on trunk lines, the three prominent electric systems and their characteristics, features of steam and electric operation respectively, the economics of electrification.

History and Status of Electric Traction

The first period in the application of electrical energy for transportation, from about 1830 to 1860 was marked by experiments in connection with permanent magnets, reciprocating motion, and later with chemical batteries of very limited capacity. The next period began with the development of the electric dynamo and its subsequent use as a motor. Between the years 1863 and 1887 a great number and variety of miniature electric railways, and later heavier street railways, were built, and operated for short periods. The next period, and a very brilliant one for electric railways, may be said to date from 1888, for in that year the first commercially successful electric street railway in America began operation. It was installed by the Sprague Electric Railway and Motor Company, at Richmond, Va., and is the pioneer of the now familiar trolley systems seen in the streets of our cities and on the highways of our country. The next period of activity began about 1893, when the practical application of electricity for traction under conditions comparable with those obtaining on steam roads, took place.

In 1893 the Intramural Railway, at the Chicago World's Fair, first demonstrated the availability of electricity for heavier traction purposes than street railways. The distinctive feature of this installation was the first use of the third rail.

In 1895 the Metropolitan Elevated Railroad, of Chicago, was built, thus utilizing the principle which had been demonstrated by the Intramural, and three years later a considerable advancement was made when the "Multiple-Unit System" was first put into service by the South Side Elevated Railway of Chicago. This installation displaced steam locomotives, which course was afterwards followed by the elevated railroads of New York City.

The first real invasion of the steam railroad field occurred in 1895, when the Baltimore and Ohio Railroad began to operate all of its ordinary freight and passenger trains through the Baltimore tunnel with heavy electric locomotives. These electric locomotives were designed for pusher service through the tunnel, which, although not long, contained a heavy continuous grade. This installation clearly demonstrated the physical possibility of heavy electric traction.

The next large heavy traction electrification was that on the Long Island Railroad (one of the Pennsylvania roads), which was put into operation in 1905. The traffic consists almost wholly of a dense local suburban passenger service out of New York City. This electrification, which is one of the most important in America, is thus described by Mr. J. A. McRea: "In 1905 the Long Island Railroad began electric operation in connection with what was known as the Atlantic Improvement, which consisted of the elimination of numerous grade crossings in the borough of Brooklyn, and the re-construction of about nine miles of road. These improvements made necessary the elimination of steam as a motive power, and the work on these nine miles spread out until about 30 route miles were equipped to start with. This has been constantly extended until we now have about 62 route miles of road and 164 miles of track electrified. To a great extent the change was gradual, and, consequently, at no time was it necessary to change our methods, so to speak, over night."*

The Long Island electrification was followed in 1906 by a similar equipment of the West Jersey and Seashore (another Pennsylvania line) Railroad, a line running from Camden to Atlantic City (a distance of 65 miles). For 30 miles out of Camden the road serves a suburban territory, but on the remaining portion the local traffic is small. This may be considered the first example of electric traction for main line express service.

In 1906 the New York Central and Hudson River Railroad began electric operation of its New York City terminal. This is the first example of a very heavy trunk line terminal electric operation for all passenger trains. In connection with the electrification, the terminal was remodelled to secure greater capacity and convenience. It is planned to extend the electrified portion on both the Hudson and Harlem divisions to embrace a large suburban zone.

The New York Central electrification was followed in 1907 by the equipment of the New York, New Haven and Hartford Railroad into New York City, dictated primarily by the condition of its entrance over the New York Central tracks into the Grand Central Station. The first equipment was designed to conduct, by electric locomotives, a very dense local and through service on a four-track railway for 34 miles out of New York City. Of this distance 13 miles are over New York Central tracks. This initial electrification covered about 100 miles of single track, but greater extensions have since been made.

In 1910 the management of the New York, New Haven and Hartford Railroad decided to extend their electric service to cover passenger, freight and switching service under trunk line conditions on the Harlem River branch. This extension, which connects with the present main line electrification at New Rochelle Junction, will, when completed, enable all train and switching movements on the New Haven system west of Stamford to be made electrically. By this electrification some 200 miles of track, measured on a single track basis, will be added to the 100 miles already electrified.

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* "Notes on the Electrification of the Long Island Railroad," by J. A. McCrae. Proceedings of New York Railroad Club. March, 1911. Page 2354.

In September, 1910, it was decided to electrify the Hoosac Tunnel and approaches, including yards at each end. On May 18, 1911, the first train was drawn through by electric power, while continuous electric operation of the total traffic was begun on May 27, 1911. (It might be stated that the Boston and Maine is a part of the New Haven system.) This electrification includes the tunnel, east and west portals, and yards at both ends, aggregating 21.3 miles of single track.

There was, therefore, 121 miles of track under electric operation on the New Haven system in the summer of 1911. The electrification of 200 miles (as before stated) more is now proceeding, while, doubtless, the New Haven extension, including 150 miles more, will follow.

The New Haven electrification may be regarded as the most important, distinctively trunk line, electrification at the present time on any railroad.

In 1908 the Grand Trunk Railway electrified its St. Clair Tunnel. This is an example of electric haulage of all trains through a heavy grade sub-aqueous tunnel. The tunnel is a link in the main line of the railway between Sarnia, Ontario, and Port Huron, Michigan. The electrification covers 12 miles of track.

In 1909 the Great Northern Railway completed the electrification of its Cascade Mountain tunnel, in the State of Washington. In this tunnel (as was also the case in the Baltimore, the St. Clair, and the Hoosac tunnels) the conditions obtaining with steam operation were very bad (it is on record that the temperature in an engine cab rose as high as 200 deg. F.), and a safer and more efficient operation was demanded. As the Cascade tunnel was recognized as the limiting feature of the capacity of the Great Northern Railway for hauling freight across the mountains, the desirability of electrification is obvious. The availability of water power was also a determining factor.

The first railroad to be built for the handling of both freight and passenger business, under substantially steam railway conditions entirely by electricity, was the Spokane and Inland Empire Railway. This road was first operated in 1906 (i.e., the single phase section). Notable features of the installation are: The great extent—160 miles of track under single phase; 58 miles of direct current interurban, known as Coeur d'Alene and Spokane Railroad; 52 miles of city street railway, known as

Spokane Traction Company; the utilization of water powers; the heavy grades and curves, one grade being 2 per cent. and seven miles long, with numerous curves.

In the autumn of 1910 the Michigan Central Railroad put its new Detroit River double track (double tube) tunnel into operation. Electric locomotives now haul freight and passenger trains through the tunnel. Previous to the construction of the tunnel, trains were taken from Windsor to Detroit and vice versa by car ferries, and operation in winter was very troublesome. The electrification includes tunnel and yards at each end; total mileage is 19.

On Nov. 27, 1910, the Pennsylvania Railroad began service on their New York City terminal system. The construction of the tunnels, terminal station, and the electric motive power in connection with this terminal has been described as the greatest railroad work in history. The service is a very heavy passenger load, through the local, into the heart of New York City. It is a most significant fact that the general scheme carried out was only made possible through the wonderful development of the art of electric traction during the last few years. This electrification covers 108 miles of track. As in other terminal systems of similar character in large cities, two methods of operation are in use, namely, heavy locomotive-hauled trains for through service (Pennsylvania Road), and multiple-unit motor car trains for the local and suburban service (Long Island Road).

The foregoing much-abridged review of heavy electric traction installations includes only the more important electrifications under steam railway conditions, and it is evident that electric traction is in extensive use under a great variety of conditions.

The history of railroad electrification shows that electric traction was first considered for special situations, where possibly, economy of operation was not the most important factor. Later, the field broadened, due to the demonstration of physical and financial advantages. The general trend of electrification on trunk lines has been, firstly, tunnel electrification; secondly, passenger terminal electrification, including suburban service; thirdly, small freight terminals and extension farther and farther from the centres of dense traffic.

Electric Traction Systems

For traction work in general, a great variety of electric systems has been proposed; for electric traction under trunk line conditions there are now three distinct systems in use, namely, the direct current, familiarly known as the "third rail" system; the single phase alternating current system; the three phase alternating current system.

It is of prime importance to know the costs connected with the various systems, and since costs are determined by the inherent characteristics of the systems, a knowledge of those characteristics is of interest and importance in comparing the systems. In this connection, brief analyses of the three systems before mentioned are given.

The Direct Current System

Direct current at 500 to 650 volts is in almost universal use for city trolley systems; 1,200 and 1,500 volts have been used of late years in several interurban lines, and it has been proposed (by Sprague, in America) to use 1,200 volts for trunk lines; but for heavy railroad service 650 volts is now standard, and bids fair to continue so in its particular field.

Power for direct current railway work is generated as three phase alternating current at convenient voltage and frequency, 25 cycles being almost universal. The voltage is raised by transformers, in groups of three, to the transmission voltage, which is chosen to suit conditions—33,000 volts being a common value for tower and pole lines.

A three phase high potential (11,000 volts to, say, 60,000 volts) transmission line is required, in order to secure economical transmission of power.

On account of the low voltage employed for distribution, it is necessary, in order to prevent excessive loss of power and excessive drop, to have sub-stations placed at frequent intervals along the line. The distance between sub-stations depends upon the character and amount of the railway service—for heavy locomotive trains, sub-stations will have to be placed very closely along the line.

These sub-stations contain lowering transformers in groups of three, and rotary converters (seldom motor-generator sets) for changing from alternating current to direct current, also the accompanying apparatus. Direct current sub-stations require constant attendance; this makes the operating cost high. Since the sub-stations are installed comparatively close together, and since railway loads fluctuate violently, the load factor of the converters is rather low; this fact means low efficiency of underloaded rotaries, also, a more serious fact, it means excess equipment having heavy fixed charges.

In connection with the converter sub-stations, storage battery installations are sometimes used to improve the load factor and to insure against stopping of trains when central station power is cut off.

To conduct the current to the trains, a heavy "third rail" conductor is used. This third rail is supported by insulators from the ends of the ties and may have various forms of "protection" to lessen danger to employees and passengers. To collect the current, a heavy contact shoe suspended from the locomotive or car is made to slide over or under the third rail. "Track return" is used, and to accommodate the heavy currents, the track rails must be heavily, hence expensively, bonded. For heavy railroad service it is often necessary, on single track lines, to supplement both third rail and track rails by heavy "positive" and "negative" feeders.

Direct current railway motors are of the "series wound" type. They have long been thoroughly tried and standardized, and are recognized as having characteristics most desirable for traction service. The recent introduction of interpoles has further favored the design of these motors, and they are now built in extremely large sizes (1,000 H.P., also allowing 2,000 H.P. for half-hour period), and are capable of standing severest service.

For direct current motors rheostatic control is used in combination with the "series-parallel" system of motor grouping. With this system considerable power is wasted during acceleration, and there are but two or three (with four motors) efficient running speeds, namely, the "series" and the "parallel" speeds. However, since the advent of the interpole it has become practicable to employ field control for giving a greater speed range with efficiency.

The direct current system is convenient for the equipment of motor cars for multiple unit service.

The Single Phase Alternating Current System

Since the advantages of the single phase system are almost all due to the high potentials practicable with this system, it is customary to use much higher voltages with this type than with the direct current system. For heavy service, 6,600 volts and 11,000 volts are general, the latter being favorite where locomotives are much used. Two frequencies are standard, namely, 25 cycles and 15 cycles. 25 cycles is almost universal in America, while 15 cycles is now favored in Europe. The selection of a standard frequency is a very complicated problem. For trunk line service, in which locomotives are used, there seems to be little doubt but that 15 cycles is preferable to 25 cycles, and 15 cycle apparatus may gain a foothold in America in the near future. Stillwell says: "Concensus of opinion now is in favor of 15 cycles rather than 25 cycles for single phase working."*

For single phase railway work, either single phase or three phase generators may be used. The use of three phase generators make switching arrangements more complicated, but it also allows the utilization of polyphase current for shop use and similar service. It is not much more expensive to use three phase genrators for single phase distribution, as the new type of dampened field cuts down the rising voltage on the idle phase, making it possible to use three phase for commercial requirements. The generators may be direct connected to the contact system—which is good practice up to 11,000 volt generators —or step up transformers may be used if desirable.

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* Discussion on "The 1,200-Volt Direct Current Railway System." L. B. Stillwell Transactions A.I.E.E. Vol. XXIX. Part 1. Page 20.

If the electrification covers a very considerable distance, say 25 to 50 miles each way from power house, with 11,000 volts, it may be desirable to use a high potential transmission line to feed the trolley system. This line would be single phase. Single phase railway sub-stations are merely step down transformers, with their minimum of auxiliary apparatus interposed between transmission line and distribution system. Being very widely spaced, these sub-stations have the best possible load factor. The efficiency is high and no attendance is necessary. Thus it is evident that these sub-stations are cheap in first cost, and have low operating costs; also of great importance is the fact that they are few in number.

To show how widely sub-stations may be spaced, the example of the New York, New Haven and Hartford Railroad may be cited. On this road, 11,000 volt generators feed directly to the trolley system. No sub-stations are used, and at peak load (5.30 p.m.) the voltage at Harlem River Station, which is 25.6 miles from the central station, is 9,151 volts. This is claimed sufficient to maintain all passenger and freight trains on schedule, and to furnish at the same time the necessary power to switching engines doing duty on 100 miles of classification and switching yard tracks, which are a part of the Harlem River branch electrification, and which are located most remotely from the power house.

The working conductor in the contact system is an overhead copper, alloy, or steel wire suspended by means of "single" or "double" catenary arrangement in a plane, parallel to the track, and at a height above the track of about 22 feet in American practice. The catenary suspension system readily lends itself to all conditions met with in trunk line service, and notably for large freight yards. Track return is used, hence rail bonding is necessary, but bonds are light and inexpensive on account of the small currents carried.

The locomotives and motor cars collect current from the trolley wire by means of an overhead pantograph, which carries a contact shoe, bow, or roller. The line voltage is stepped down to the motor voltage by means of a transformer, which is arranged with a number of taps, for supplying various voltages to the motors. The type of single phase motor used is the series compensated type, which possesses characteristics very similar to those of the direct current series motor The single phase motor, however, is heavier than the direct current motor of similar capacity. It also requires a transformer of considerable weight, and, including the control apparatus, the alternating current equipment is much heavier than the direct current equipment.

Control of motors is secured by voltage variation, which is easily obtained by the use of numerous transformer taps. The taps are taken to the controller after passing through a system of "preventive coils," the function of which is to obviate breaking the circuit and short-circuiting transformer coils, on passing from step to step. This method of control allows of very wide range of efficient speeds. Every controller position is an efficient running position; it also enables the motorman to compensate for drop in the line and to overspeed in case of delay.

As before mentioned, single phase equipment is heavier than direct current equipment, but it is obvious that the difference in weight will be only a small percentage of the weight of a heavy train. The conclusion is that the weight of equipment is a relatively unimportant item in the operation of locomotive trains with long runs, but for a high-speed, frequent-stop schedule, as carried out on many roads by means of multiple unit motor car trains, this item assumes greater importance.

Perhaps the most remarkable features of the single phase (series compensated) system are its simplicity and flexibility. As illustrating these two points, reference is again made to the New York, New Haven and Hartford Railroad electrification. The simplicity is well shown by the following statement by Murray: "The New Haven system provides that the volt manufactured in and leaving the doors of the power house is the same physical volt that knocks at the doors of the locomotives. Thus the line is the single link that unites the power house and the locomotives. All such adjuncts as step-down transformers, synchronous converters, storage batteries, low-voltage distributing systems, with their necessary complement of help, are dispensed with."* The flexibility is shown by the fact that the New Haven trains pass at full speed from the New Haven zone, in which 11,000 volts alternating current and overhead conductor are employed, to the New York Central zone, in which 650 volts direct current and a third rail conductor are employed. The motorman changes from alternating current control to direct current control or vice versa by simply throwing a set of double-throw switches. Of course, such interchangeability is accompanied by increase of complication, weight, and cost of equipment.

The Three Phase Alternating Current System

The three phase system is used in trunk line service by only one American road, namely, The Great Northern Railway, which has been referred to before. This electrification makes use of 6,600 volts at 25 cycles. The European standards are 3,000 volts and 15 cycles.

The power for this system is generated as three phase alternating current at desired voltage (3,000 or 6,000 say) and frequency. If the system is at all extensive, a three phase high voltage transmission line is necessary.

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* "The Log of the New Haven Electrification," by W. S. Murray. Proceedings of A.I.E.E. Dec. 1908. Page 1658.

Sub-stations for this system resemble the single phase railway substations, except that transformers in groups of three are used; also, due to the lower working voltage of the three phase system sub-stations must necessarily be more closely spaced on three phase than on single phase lines.

Two overhead conductors, suspended by catenary system are employed for contact. Due to the high voltage between the two lines, the overhead construction is difficult and expensive at switches and is prohibitive in large freight yards such as exist in America. Track rails are bonded as in the case of the single phase system.

On the Great Northern locomotives, transformers are used to step down the voltage to 500 volts, for the motors; in Europe 3,000 volts are used directly on the stators. With this latter system, drop on the line must be kept down to a minimum, as it has a serious effect on the motor torque, which torque varies as the square of the voltage.

The three phase induction motor is used on three phase traction systems. This motor is inherently a constant speed motor. This means that under ordinary circumstances it would run at almost the same speed up a heavy grade as on the level, although in the former case the horse power output would greatly exceed that required in the latter case. Changes of speed can be effected by changing the secondary resistance, but this is a very wasteful method. Cascade control is used to obtain lower speeds with higher efficiency than is obtainable with straight rheostatic control. Also, the synchronous speed may be halved by employing a system of "pole-change," that is, by changing over to one-half the number of poles. Both concatenation and pole-change introduce complications in the control system, but are necessary to obtain efficient control.

The three phase motor is of rugged construction, requires no commutator (general type), and enjoys the advantage that a greater continuous output can be secured within a given space than by any other form of motor. Another advantage of the three phase motor, which is of great importance on mountain divisions but unimportant on most divisions of trunk lines, is that "regeneration" on down grades is very easily accomplished. This latter point was a factor in the decision of the Great Northern Railway to employ three phase.

It might be stated that there are two results desired in regenerating, namely, to economize power and to secure more reliable and cheaper control of trains on heavy grades. The maintenance cost of air-brake rigging on mountain divisions is very heavy; also, due to certain limiting features in connection with air brakes when used to control heavy trains, especially long freight trains, on long grades there is a danger of train parting.

When regeneration is practised, the duty on the brake system is greatly lessened.

Three phase equipment is obviously unsuitable for motor car service—both the overhead construction and the motor characteristics militate against its use in the class of service handled by multiple-unit motor car trains.

Selection of System

It has been often said of trunk line electrification that "every situation is a study in itself," and doubtless this is largely true for electrifications embracing trunk line divisions of limited extent and character of service, and this is the rule in most of the electrifications up to the present, which are mostly tunnel or terminal problems. It is only when an electrification is planned to embrace numerous divisions of a trunk line and to take care of all classes of traffic that the problem of selecting a "system" becomes most general. It is thus evident that cost data relating to any given electrification must not be accepted haphazard as applying to any other conditions than those obtaining in the specific case. Analysis to the last degree is necessary for the rendering of proper conclusions.

THE SCIENCE OF LEATHER MANUFACTURE

K. D. Marlatt, '08

The manufacture of leather is one of the oldest arts known to mankind, and dates far back in the prehistoric ages. Relics which have come down to us from Palaeolithic times, together with the experiences of modern explorers, prove to us that agriculture is of more modern development than hunting, and as the hunters had—at least in certain climates—to wear clothing, it is only natural to deduce that they must have used skins of animals for this purpose. They must have found that when the skin dried, it became hard, except at the places where there was a great amount of fat upon it, and that there it remained soft; so that the next step was to cover it with grease before drying, and thus the first leather was probably made. Then it was found that smoke also had a preservative action, so that the skins were covered with grease when held in front of a fire, in order that the smoke could blow upon them. The North American Indians made their leather in much the same way. The next step was to dye the skins with berries and barks, and so they found this also preserved the skin, and therefore they started to treat the skins with infusions of bark or berries, and thus laid the foundation for all vegetable tannage.

We have many references made to leather in the early books. In the "Iliad", Homer refers to the making of leather by putting grease upon the hide. In the time of Abraham, boots and shoes are spoken of. Also a mummy of the year 4600 B.C., was found wrapped in a quilt of tanned and dyed sheep skins. An old carving from Syria also shows men unhairing and tanning 5900 years ago. Even in these olden days they knew how to emboss the leather. The Romans also were great tanners, and then the Moors.[1]

To come to more recent times, in the reign of Queen Elizabeth an Italian doctor of her court, under patent from her, introduced Sumac tanning into England. Sumac now is used extensively in light leather manufacture. In the years 1605, 1606, 1067, laws were made in England controlling the tanning industry, and some were very strict; one was, that any tanner who was found selling leather, which had not been in tan for three years was imprisoned, whereas, to-day some tanneries tan the same kind of leather in as many weeks.

In the year 1865, Prof. Knapp tanned the first Chrome leather. This is a chemical tannage, and is more rapid than any vegetable tannage, and has almost superseded bark for tanning light leather, and is also used for tanning heavy leather.

In this paper I shall chiefly deal with the manufacture of heavy leather, according to the English method. Let us first consider the hide itself. (1) The supply; (2) Preservation; (3) The hide structure.

The Supply

In England there are three classes of hides; (1) Shorthorns (Scotch breed); (2) Herefords; (3) Lowlands, and for value they rank in the order they are given.

Then there is the continental supply, which may be divided into two classes, those from the hilly regions, and those from the lowland regions. The former are much stronger and firmer hides owing to being exposed to severe climatic conditions.

There are also the Chinese hides, which are dried; hides from Australia and kips from India; South American, Canadian and United States hides, of which the Packer hides are the best.

Preservation

There are many methods of preserving hides, but the two commonest ones are by salting and drying. In both cases the principle is the same, namely to extract moisture from the hide, for putrefaction can take place only in the presence of moisture. Salt in itself has only slight antiseptic action, but it absorbs the moisture from the hide. In drying, the same object is in view, but it is a rather dangerous method, for if the hide be not dried fast enough putrefaction will start, and the hide goes to pieces when soaked, and if dried too rapidly, the hides cannot be softened with a reasonable amount of labor. Phenol, arsenious acid, salicylic acid, boracic acid, and several other chemicals are used as antiseptics.

The Hide Structure

A hide is formed of two parts:—

(1) Epidermis: (a) Upper layer, or horny layer, (b) lower layer

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[1] Professor H. R. Proctor.

or *Rete Malpighi.* (2) The Corium (a) The Epidermis has to the completely removed in liming, if not one gets bad grain and bad color.

The epidermis is of cellular structure, each cell grows and then breaks up into several small cells. The more nourishment they receive the more quickly they grow. They are forced flat as they approach the surface, and so change from the *Rete Malpighi* into the horny layer.

The upper layer of the epidermis is not attacked in liming, but only the lower layer, or *Rete Malpighi.* This soft mucous layer is attacked and dissolved thus the horny layer being separated from the corium comes off in unhairing. In sweating the bacteria liquefy the *Rete Malpighi*, and so the hair is loosened.

The corium is of fibrous, not cellular structure. The fibres do not increase as the cells of the epidermis do, nor does the hair ever enter the corium. The fibres on the flesh are in bundles and interwoven, but as they get nearer the grain side they become finer, until at the grain itself they are single fibres, and more tightly interwoven, the fibres lying in a parallel position. The hair grows downwards, and takes the epidermis with it (in the epidermally surrounded sac). The root takes up the nodules of lymph of the corium, and feeds on them. Each hair is pushed out by a new one every year. The nodules of lymph are the life of the skin and the food which builds up the whole body. The lymph is a colorless fluid. The skin is bound together by elastic fibres, sometimes spoken of as yellow bands; these are dissolved in liming, and so the hide plumps and swells. The hide contains numbers of globules of grease, and the coarser fibres are full of them.

The hide is permeated with interfibiller substance, which is gelatinous, and which gradually changes to fibres. Pigment cells are in the root of the hair, and dye the same, and each hair has at least two fat glands. There is a net skin between the corium and the meat proper, this is removed by fleshing.

The formula for hide substance is not definitely known, and is very complex, but it is taken as being the same as gelatine minus one molecule of water, and one accepted formular for gelatine is, $C_{76}H_{124}N_{24}O_{29}$ which is rather a formidable formula.

Leather Manufacture

The actual manufacture of leather may be treated under several heads:

(1) Soaking
(2) Liming
(3) Bating
(4) Tanning (English Oak Sole leather)
    (a) Suspenders (c) Dusters
    (b) Handlers (d) Layers
(5) Scouring
(6) Drying
(7) Finishing

Soaking

When the hides are taken to the Beam House, the first object is to get them back as closely as possibly to the condition they were in when taken from the animal's back. With this object in view they are put into soaks, which are large vats filled with cold clean water, and they are left for two or three days, and the water on them is changed several times, and as the object of soaking is to remove all the dirt, blood, salt, or other preservatives, it is necessary to use clean water; and another reason for this is that when a soak liquor is allowed to get old, bacteria develop, and these dissolve the hide substance, and you lose weight. Hide substance is also soluble in warm water, so it is necessary to use cold water in soaks.

In soaking dried hides, old soak liquors are sometimes employed, since owing to the activity of the bacteria the hides soften more quickly than in fresh water, but this is a dangerous practice, as, if not watched carefully, much hide substance is lost. A better method for treating dry hides is to use a little Sodium Sulphide, or Sodium Hydrate with the clean water for part of the time they are in soak, and end by running in a latticed drum.

Liming

When the hide is in the proper condition, it is removed from the soak, and fleshed, that is, the rough flesh is taken off either by hand, or machine, and it is then put into a lime. There are a number of methods of liming, but in sole leather they generally use from 7-9 lbs. of lime per hide, and lime for 8-12 days. The amount of handling they get varies in different yards. Or Sodium Sulphide may be employed, in which case the quantity of lime used, and the time are both reduced, We might divide up the liming of heavy leathers into three classes:—

(1) Sole leather
(2) Harness and Belting leather
(3) Dressing leather, carriage, automobile, etc.

(1) Sole leather requires a short sharp liming, that is to say you wish to get the maximum plumping in the minimum time, and so the limes are never allowed to get very old. However, you must not underlime or you get a cracky grain.

(2) Harness and Belting leathers must be more pliable, and you use more mellow limes, that is to say, limes which are a little older.

(3) Dressing leathers should be soft and pliant, and you use still more mellow limes, and never make up an absolutely fresh one. Lime is soluble in water only to a very limited extent, 2-3 oz., pure lime, to 1 cubic ft. of water, or 1 part lime to about 778 parts cold water; however, as the purity of lime runs from about 60%, 80%, or 90%, and also as lime gets used up, it is necessary for one always has to use a large excess. Lime is one of the very few substances that is more soluble in cold than hot water.

In liming, three actions take place, namely, bacteriological, chemical and physical.

The bacteriological section is the action of bacteria on *Rete Malpighi*, that is to say, the peptonisation. The chemical action is the dissolving of the peptonised *Rete Malpighi*, hair bulb, lymph, and grease which latter is converted into a calcium soap. The physical action consists in alkalinity of the limes swelling and plumping the hide, and splitting up the bundles of fibres held together by the yellow bands.

The first action is the alkalies swelling and plumping, and then the bacteria work down the hair, and hair sac, peptonising the *Rete Malpighi*, and hair bulb, which when peptonised is soluble in lime, and the epidermis, and hair can be pushed off.

In using lime, unhairing is possible only by bacterial action. That is to say, unless limes were exposed to the air no unhairing would take place, for in a sealed lime a hide will not unhair. In this and other respects, lime differs from sodium sulphide, one of the commonest depilating agents. A comparison might here be given.

Lime	**Sodium Sulphide**
(1) Dissolves *Rete Malpighi* and so loosens hair only by bacterial action.	(1) Dissolves *Rete Malpighi* without bacterial action.
(2) Dissolves the yellow bands by swelling and plumping hide.	(2) Same as lime.
(3) Does not dissolve hide albumen.	(3) Dissolves hide albumen slightly more than lime.
(4) Forms insoluble calcium soap with fats and greases.	(4) Forms soluble sodium soap with fats and grease.
(5) No effect on hair.	(5) Destroys hair.

Lime and sulphide work together, and give excellent results, for apart from the action of the lime and sodium sulphide alone, one also gets developed double sulphides of calcium and sodium which play an important part in liming and also sodium hydrate is developed and this latter has very great plumping power. Another method employed for depilating in Canada and the United States is sweating. This method is briefly as follows. The hides are hung in a sweat pit at a temperature of 75 degrees-80 degrees F., and the temperature is controlled by a jet of steam blown in at intervals or by water sprinkled into the pit from above, depending upon whether you wish the temperature raised or lowered, and so the hides are always kept moist. After 4-6 days the hides are unhaired. In this method the unhairing is almost entirely due to bacteria which attack the hide and peptonise the *Rete Malpighi*, and if left too long the bacteria attack the hide itself. Ammonia is developed by the decomposition of organic matter, and this also aids in the depilating. In this method the hide is not properly plumped, nor is the grease killed, and so it is necessary to treat the hides with acid before tanning.

After liming, the hides are unhaired either by hand or machine. The treatment of the hide from here on varies with the class of leather to be made.

Generally speaking, sole leather and harness and belting leathers are usually delimed by acid, that is to say, the hides are put into a vat with water, which has been weakly acidified with one of the following acids, sulphuric, lactic, formic, acetic or boracic. They are usually left until the lime is nearly neutralized, and then they are skudded on a beam, or run in a drum with water, to wash out the dirt. In making dressing leather, on the other hand, the treatment is different, and here the hides are bated. That is to say, they are put into a paddle with an infusion of hen manure, and run on and off for one or more days.

The bate has two chief actions:

(1) It neutralizes the lime present.

(2) It produces a certain amount of liquefaction of the interfibiller substance, thus pulling down the hide, and giving it a more mellow and pliable feel.

The first action is due to acids, and the second to bacteria. These actions may be expressed in another way.[1]

(1) Action of organized ferments

(2) Action of unorganized ferments

(3) Chemical action.

Many artificial bates have been made, but none that I know of, give as good results as the natural bate.

From the above outline, the reader can gain some idea of the tremendous influence different bacteria have on the hide in the early stages of leather manufacture, and even to-day their influence is not completely understood.

From the beam house the hides go to the tan yard, and here the methods are so diverse, not only between the different kinds of leather, that is, between sole, harness, dressing, and belting leathers, but also as there are innumerable methods for the tannage of each of these classes, that in this paper I shall take for a good example, the tannage of English oak sole leather. But first I shall speak of some tanning materials. These are divided into two classes, the Pyrogallol and Catechol tans.

The pyrogallol tans are those which have a plumping effect upon the leather, due to the acid they form when they ferment. They also deposit what is known as bloom, but which is really ellagic acid. Leather tanned with a pure pyrogallol tan does not change color on exposure to light.

The Catechol tans are those which do not have a plumping effect on the leather, and they do not sour and develop acid. They do not deposit bloom, but instead a sticky resinous matter called "Reds." Catechol tanned leathers are affected by light.

There are also a large number of chemical reactions to distinguish these two classes.

Some of the commoner pyrogallol tans are:—

(1) Myrobalans, obtained in India, 27% to 39% tan, and chestnut, an extract made from the wood, containing generally 25% tan.

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[1] Dr. J. G. Parker.

(2) Divi Divi, Central America, 40% to 50% tan.
(3) Sumac, Italy and Sicily, 28% to 30% tan.
(4) Algarobilla, Chili and India, 45% tan.

Some common Catehol tans are:—

(1) Gambier, Singapore, Straits Settlements, 25% to 40% tan.
(2) Mangrove, West Africa and Borneo, 4% to 40% tan.
(3) Quebracho, South America, 20% tan (generally used as an extract).
(4) Mimosa, Australia and Natal, 32% to 42% tan.
(5) Hemlock, Canada and United States, 8% to 11% tan.

Oak bark runs from 12% to 14% tan, and is chiefly a catechol tan, but has certain characteristics of the pyrogallol class, and so is said to belong to both classes.

Valonia, like oak bark, also seems to belong to both classes, but is chiefly a pyrogallol tan. There are two kinds of valonia, namely: Greek, 26% to 30%, and Smyrna, 32% to 36%.

The Process of Tanning

The object of tanning is to convert an easily putrescible substance, namely, the hide, into an almost imputrescible substance, leather. In tanning there are three actions:—

(1) Chemical:—Coagulation of the gelatine.
(2) Mechanical:—Deposition of "Bloom" or "Reds."
(3) Physical:—Coloring and plumping of the hide.
(4) Tannage of English Oak Sole leather.

After hides are unhaired they are put upon a table and "Rounded," that is, cut into butts, bellies, and shoulders.

I shall only deal with the tannage of the butts, since the bellies and shoulders get much the same treatment, only do not get so much attention.

Suspenders

After deliming, the butts are hung from straps, or in some other manner suspended in the first of a series of several pits, usually about nine in number, the strengths of which increase steadily from 8 degrees Barkometer. The butts are handled out of the liquors every day, and every other day they are moved forward one pit. They are in the suspenders for three weeks.

Handlers

From the suspenders the butts are put into handlers, or a series of pits in which the butts are piled flat, one upon the other. The strength of liquors runs from 18 degrees Barkometer to 22 degrees Barkometer. They remain in the handlers for four weeks, but are handled every day or every other day. When the butts come from the handlers they are about 70% tanned.

Dusters

From handlers they go to what are known as dusters, which are a series of pits of different strengths, 23 degrees, 25 degrees, 27 degrees, 30 degrees Barkometer, and in each pit the butts are laid flat, and then sprinkled or dusted with oak bark, or oak together with some other material. The butts start in the weakest liquor, and remain in for one week, then they are handled to the next pit, and so on. As the butts lie in this liquor the "bloom" gradually becomes deposited upon them and slowly is taken up by the butt, and so weight is got into the leather. This bloom also has an important effect upon the wearing quality, it greatly increases it. It also tends to make the leather more waterproof.

From the dusters the butts go to the layers, where the butts are laid flat in the vat and each one covered with bark. There are generally seven of these:—

(1) 30 degrees Barkometer, and they remain 2 weeks.
(2) 32 “ “ “ “ “ 4 “
(3) 35 “ “ “ “ “ 4 “
(4) 38 “ “ “ “ “ 4 “
(5) 40 “ “ “ “ “ 4 “
(6) 48 “ “ “ “ “ 4 “
(7) 50 ‘ “ “ “ “ 4 “

In the layers we have much the same things happening, as in the dusters. First the tannage is completed, and the bloom is then deposited upon the butts, and gradually taken up by them.

But only the heavy butts go through all seven layers. The light butts go through only two, and the medium, four or five.

The chief material used in the tanning of the above leather is oak bark, this is put through a grinding machine, and cut and crushed up into small pieces; this ground bark is then put into large—usually circular—vats, called leaches, and the tannin extracted with hot water. It requires several changes of water to get all the tan out. It is the general custom to make the first extractions with a tan liquor, and then use hot water.

You can only get about a 35 degree Barkometer liquor from oak bark, therefore to get the last four layer liquors, it is necessary to use some Valonia, or some Myrabolans are also used. Roughly speaking, the liquor starts with the strongest layer, and then is gradually worked down the yard to the suspenders, and from there is pumped up to the leaches again and used over.

After the butts come from the layers, the adhering bark is brushed off, and they are quickly rinsed through a weak liquor, and then piled and let drip for two days. Then they are hung up in drip sheds, which are almost air-tight sheds, and allowed to partly dry and solidify, until they are in an India rubbery condition, then they are taken down and piled to heat, and then scoured.

Scouring

The object of this is to remove from the grain the "Bloom" that has been deposited on the butt in the layers. This used to be done by hand, but now it is done chiefly by machine. The butt is placed on a movable table, and worked under the arms of the machine, which are fitted with stones and brushes, and a certain amount of water is put on the butt, and the bloom is worked out of the grain. The amount of bloom taken out depends on three things:—

(1) The pressure used,
(2) The angle of the stones,
(3) The amount of water used.

After scouring the butt is pinned or struck out, that is to say, the butt is stretched and the grain smoothed down as much as possible.

Finishing

After pinning the grain of the butts is wiped clean with a wet cloth. Then the water is wiped off, and the grain dried by rubbing with a piece of dry flannel, after which the butt is oiled, usually with cod oil, on the grain.

The objects of oiling are (1) to get a soft pliant grain; (2) to make a rather waterproof surface on the grain, so that most of the drying takes place from the flesh side, and so prevents the strong liquors from drawing up to the grain surface, and so spoiling the color.

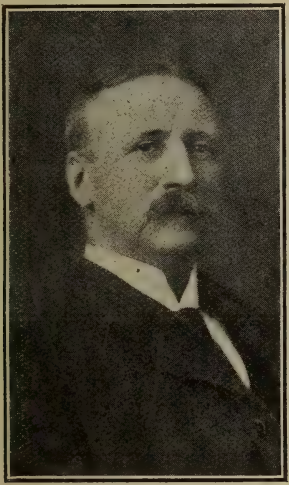
After oiling the butts are hung up in a shed, and dried slowly until just showing dry upon the edges. They are then taken down, and piled and allowed to sweat and again pinned, and again the grain is wiped clean, dried and oiled, and the butts are hung up till partly dried. Then they are rolled (rolled on) under a light pressure, and then hung up and dried still more, until the color shows up, and are then again rolled (rolled off) under a heavy pressure, and then dried out and polished, and are ready for sale.

L. T. Burwash, M.E.

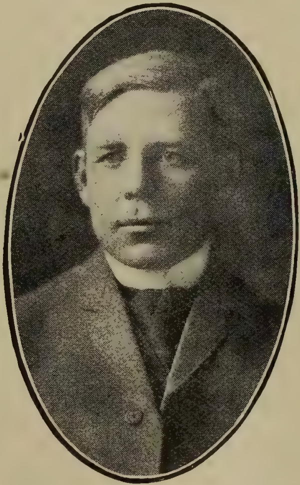
At the conferring of degrees in Convocation Hall on June 7th, 1912, L. T. Burwash, '96, should have been there to receive from the hand of the Chancellor the degree of Mining Engineer, having very successfully qualified for the same. His thesis entitled "The Development of Placer Mining in the Frozen Gravels of the Yukon," is a veritable masterpiece containing information the equal of which has not been compiled heretofore in the interests of the great Yukon.

A graduate in Mining Engineering with the class of 1896, and a student in post-graduate work in the following year, Mr. Burwash set out for the Yukon in the spring of '97 in the employ of the North American Transportation and Trading Co. as its civil and mining engineer. During that year his work included: a track survey of the Chilcoot Pass; a general report on the upper six hundred miles of the Yukon River, with reference to navigation and transfer points; a surface and underground survey of the company's entire holdings; a three months' location at Bonanza Creek in charge of placer operations; and a report on the Coal Creek coal properties with data relative to some fourteen miles of tram roads. The fall of '98 and the following winter were spent in placer operations.

In June, 1899, Mr. Burwash entered the employ of the Canadian Government in the Gold Commissioner's Department. Six months later he was placed in charge of the Stewart River district as mining recorder and performed, in addition, the duties of mining inspector and Crown timber and land agent. Remaining in Stewart River district until July, '03, during which time he acted as general inspector for the Federal Government, reporting upon new districts, timber and lands, and water for power and mining, he was then transferred to the Kluane district in the same capacity, where similar work was performed until it was, likewise, completed in October, 1905. Whitehorse district was the next in line for a like development, and occupied Mr. Burwash's attention for five years, the work being similar to that in the foregoing districts as regards lands, timber and water. The mining included extensive copper, silver-gold, antimony-silver and silver-lead development work.



G. H. DUGGAN, '82



L. T. BURWASH, '96

In 1910 Mr. Burwash was appointed Government mining engineer, stationed in Dawson City. The work consisted mainly of reports on mining, timber and land values of new sections; reports on water for power; hydraulic flume, ditches and pipe lines.

During the whole period of his connection with the Government, an important part of his work has consisted in the interpretation and administration of mining, land, timber, water and coal laws, as provided by the Dominion Government to govern the Yukon and other organized territories.

A photograph of G. H. Duggan, '82, is also being reproduced here, it having arrived too late to accompany his biography appearing in the June number.

CONCERNING SCHOLARSHIPS

Dear Sir:

Though your appeal to the graduates concerning the research scholarships was for money and men, and neither opinion nor advice, I doubt not your interest in their views. I may venture, then, to survey this latest field in which the School man will toil.

Your scholarships have for their object the general good, through addition to the present fund of knowledge or new combinations of facts already known. It is a worthy and altruistic aim indeed. But, although this altruism **may** continue indefinitely, its continuance, if it does not depend, at least will be much encouraged by the attainment of definite results by your scholars. With your committee rests the responsibility of selecting men to carry out your ideas, and, therefore, on the means by which you propose to make this selection hangs the success or failure of the enterprise. So far as I understand the method of selection which you have adopted (after the determination of the subjects to be investigated) that candidate will be chosen whose academic standing is the highest, and whose employment in the interim since graduation has been with the best known firms. Not that this alone will be your yard stick. The folly of such a measure is obvious. But I believe that you will have no other, in most cases, and must, unconsciously perhaps, make use of it.

To maintain that honor students will not be given a preference, under the existing arrangement, is folly. It is not in human nature to be uninfluenced by the college record, especially as the appointment is made in committee with members of the University staff, who look upon such a record as the be-all and the end-all of ability. Though I have your assurance of impartiality, and though I recognize your good intentions, I can no more believe that your committee will be impartial than I can believe the average man capable of fidelity to his religion when called upon to put into practice its dictum that he shall love his neighbor as himself, when the party in question is on the next social floor, "going down."

That great academic and professional attainment can coexist with a dearth of constructive ability needs no demonstration. Witness the absence of any marked creative achievements among our graduates (though this is no proof that the talent is lacking). Yet it is by just such accomplishments that your selection will be determined. Here is a difficulty which to me seems grave.

Without the constructive faculty that can correlate the Calculus or the Logarithm with the mechanism of the planimeter and slide rule, or harness the pure science of biology to the menial work of sewage disposal, your scholarship can be little better than a specialized post-graduate course, to which no one can be expected to subscribe, other than through his taxes. This question of temperament seems to me to have a large significance; men of meagre equipment, in their youth, such as Herbert Spencer, Edison or Paul Ehrlich, may accomplish more of real worth, in the long run, than those far above them in promise, if learning and station are the criteria. If your committee can devise a way of finding men of this stamp and can rescue them from the thraldom of commercial life, rich indeed will be the reward of your efforts.

Further, we may eliminate from our category of applicants the graduate of five or more years' standing. To such, unless of independent means, the scholarship is an impossibility. Such men are usually settled in life, and no prudent man, on whose labor the sustenance of a family depended, would forsake his permanent employment to gratify a desire for research. By this time, also, the student ardour of most of us has had time to cool to such an extent that our research possibilities could be represented by a digit in the fourth decimal place. Even should the graduate be master of some technical subject (from which in all probability he derives a livelihood) can the university offer the facilities for study that accompany the practice of his profession?

But let us assume that the appointment has been made, no matter to whom, but let the scholar be a recent graduate. Can we hope for any valuable additions to our knowledge to result from the work of such a tyro in the absurdly short period of a single academic year. The experience of every graduate in compiling his thesis will convince him of the hopelessness of the undertaking. Coupled with his disability is the disquieting fact that discoveries are expected of him. The eyes of the alumni are upon him, his position is a public one, and if he fails, as fail he most likely will, he is to be humiliated by the cancellation of the scholarship.

I can find no possible escape from the premise that results are necessary. Not only do I consider the self-regard of both alumni and scholar as factors of importance, but believe their egoism and altruism to be the warp and woof of the whole fabric. Let me quote from the "Wealth of Nations": "But man has almost constant need for the help of his brethren, and it is vain for him to expect it from their benevolence only. He will be more likely to prevail if he can interest their self-love in his favor, and show them that it is for their own advantage to do for him what he requires of them." This homely logic can only be interpreted to mean that success of the scholarship will follow success of the scholar.

Could your committee influence the university to establish fellowships, available for any graduate, which would give the holder, in exchange for a limited amount of tutorial work, a reasonable use of the laboratories, free tuition, and about $500 per annum? One or several years under these conditions should enable a student to come to you with tangible evidence of ability, and a knowledge of his subject sufficient to go on with research without enacting a travesty on the word. An alternative would be to allow the student to continue his study at his own expense.

Under these circumstances your scholarship would assume the character of a prize: it would be an honor to hold the position; it would indicate in the holder a capacity for consistent effort and natural ability for research. Your scholarship could hardly ever get into the hands of the sponge variety of student who can only absorb, the variety which at present usually obtain such scholarships, through the mistaken idea that creative ability has other ear-marks than creation.

The future of the student you could easily assure in some way similar to that of the "Industrial Fellowships" of Prof. Duncan, of Kansas University, so well explained by him in a chapter of his work "Industrial Chemistry." For at the end of the student's tenure he finds himself in possession of special knowledge, perhaps a reputation; but he has lengthened his preparation for life a year or two, he has neglected to cultivate the gentle art of selling his services to advantage, and he is not one whit further ahead in the business of life. Now, by "future" I do not mean a berth on Easy Street, but, rather, after the example of Kansas University, that the alumni bestir itself in the student's interest and place him in a position in the industry in which he has worked, in order that he may continue to advance the knowledge of his chosen subject: for the alumni is far better able to successfully do this than the student. It would require but small exertion on your part, and would constitute a powerful inducement to undertake the scholarship work. But do not imagine that I mean to bait the student with any such inducement. As stated before, his qualifications I take to be some evidence of capacity for this work and only this. But having found your scholar he is too valuable a man to allow to drift off into other lines. Doing this would be akin to building a Titanic in order to cross the sea, and then turning her adrift at the conclusion of the first passage; it might get into the hands of those who could use it, but, ten to one, it would founder.

In conclusion, I may say my object is not to provoke discussion, but rather to offer what is of value in my ideas. The subject has interested me for some years, and no amount of argument only will alter my opinions; for I have yet to learn of a single great discovery that is the result, direct or remote, of a scholarship. Of the reason I assign I think you are aware. Put a truck horse on the track and the stable will seldom own the Plate. Now, scholarship awards are made on evidence of draughting ability, the man of worth takes precedent, rightly so if you like, over him who can discover, but is good for naught else. (If you have read Isaac Newton's biography you will remember that he either could not or would not "work.") The result is consistent.

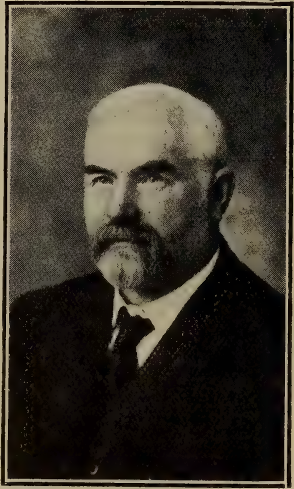
I can distinguish nothing about the "School" scholarships to indicate that they will fulfil their mission where similar scholarships fail, time and time again, or only partially succeed. And I am trying to suggest that you have means within your reach that may make the selection of a scholar less uncertain, not next year but right now.

Yours very truly,
Eddie Current.

Toronto, July 15th, 1912

BIOGRAPHY

Jas. H. Kennedy, '82



It was just thirty years ago that the graduating class of '82, a trio of men who had spent three years in association with Dean Galbraith, at the time when the institution demanded their enthusiasm and received in full measure their co-operation, took to the field. Mr. Jas. H. Kennedy, one of this triumvirate, was born in Carlton county in 1852, and enrolled as a student in engineering in 1879 at the School of Practical Science. Upon leaving the old School he engaged as rodman on preliminary survey work for the Lake Superior division of the Canadian Pacific Railway from Pic River to Missanabie, and later in the year was appointed assistant engineer on the measurement of all rock work on Section " B " of the Canadian Pacific Railway for Manning, McDonald, McLaren & Co., a firm of railway contractors, who measured the line from Rat Portage sixty miles eastward. In the following year he was successively leveller, transitman, and assistant engineer in charge of the construction on the Lake Superior division, C.P.R., which was brought to completion in 1885. This work afforded him a great deal of valuable experience and success in revising location. In 1886 he was locating engineer for the same company between Woodstock and London, Ontario, and had charge of the construction of twelve miles of this branch. In the following year, under Mr. R. Adams Davey, chief engineer for the Temiscouata Railway, he located and built twenty-one miles of road from Lake Temiscouata to Edmundston, N. B., and in the following year located a line for the same railway up St. Johns River from Edmundston to Fort Kent. Later in the same year Mr. Kennedy engaged as assistant engineer for the Montana Central Railway in laying track on the Neihart branch, and as locating engineer on the main line of the Great Northern Railway from the summit of the Rocky Mountains westward to Flathead Valley. Later he became resident engineer on construction until the completion of that division in 1892. After this he was assistant engineer in charge of the construction of about fifty miles of the Soo Line in Dakota, under the late W. W. Rich, who was then chief engineer.

Mr. Kennedy came east in '94 and engaged in private practice as land surveyor at St. Thomas, Ontario. Four years later, however, found him back in railway work again, this time for Mackenzie & Mann on surveys between the Stikine River and Teslin Lake. After the conpletion of this work, he surveyed a line in southern British Columbia from Penticton to Midway, a distance of eighty miles, and later located a fourth part of the branch. In the following year, 1899, he superintended considerable survey and prospect work for the British American Coal Co., and located a spur line from the Canadian Pacific Railway Crow's Nest line into the Coal Company's property south of the Crow's Nest Pass region.

In 1911, Mr. Kennedy was appointed chief engineer of the Vancouver, Victoria, and Eastern Railway, and constructed its line from Laurier, Washington, to Grand Forks, B.C. Two years later, during a cessation of the work, he revised the location of the Toronto & Niagara Power lines from Hamilton to Grimsby for the late Mr. W. T. Jennings. The Vancouver, Victoria and Eastern Railway work was resumed in May, '04, and from that time up to the present, Mr. Kennedy has been continuously employed on its construction work, until 1909, as chief engineer. At that time the company absorbed a number of smaller lines, and Mr. Kennedy assumed the responsibilities of the office of assistant chief engineer of the whole organization. During his connection with this company some $17,000,000.00 have been expended upon surveys and construction alone. The last division of the road, seventy-eight miles in length, to connect the Kootenay country with the coast, is at present in the process of construction. The part of this line on the western slope of the Hope Mountain is, in all probability, the heaviest construction yet undertaken in British Columbia.

Mr. Kennedy's labors in bush and field have not monopolized his time to the detriment of his knowledge of general engineering accomplishments and advancement. His engineering knowledge extends far beyond the limits of railway construction and operation. In 1887 Mr. Kennedy was granted his Ontario Land Surveyor's certificate. He has been a member of the Canadian Society of Civil Engineers since '93, and of the American Society of Civil Engineers for the last twelve years.

J. J. O'Hearn, '09, and D. D. McAlpine, '09, are with the Canadian General Electric Co., at their head office in Toronto.

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EDITORIAL

CONCERNING SCHOLARSHIPS

On another page a letter appears from one of our graduates giving his views upon some phases of the research scholarship movement. The writer strikes an emphatic chord when he states that much depends upon the selection of the scholar. More depends thereon than anyone is wont to aver at this early stage. But among the proper qualifications and other idiosyncrasies of the candidate as he defines them, he lays undue stress upon the attainment of honors during the University course, as an asset of great importance to the candidate's chances of being successful in his application.

An honor standing is, and should be, the ideal of every undergraduate. The mark is a very distinctive one in the Faculty of Applied Science and Engineering, showing that a greatly desired degree of intelligence has been displayed throughout the term and in the examination hall. But even the student is well aware that the road to success in his chosen profession is none the less susceptible to tedious problems that again and again require his best effort. He does not lean for support upon his class standing. As applied to research work, if it signifies anything at all, this honor standing implies that the applicant has more comprehensively grasped the subject matter as laid down by the curriculum than the showing made by the man of pass standing indicates. If the subject chosen for research is one bearing directly upon the work which formed the basis of his excellent standing at examination, one naturally expects the latter to be decidedly in his favor. In such a case reference would likely be made to it.

But it is much more likely that the subject for research is far remote from the work covered in the University course. Then an explicit description of what he proposes to do, backed up by an exhaustive enumeration, lending itself to clear reference on the part of the examining committee, of things already known about his problem, and his intelligent views of the possibilities his preliminary study of the subject has brought out, these are of next importance to the subject itself. Of course, this does not conclude the investigations which the committee must carry on before making an award. They must have reason to have implicit faith in the man himself and to value his intentions. They do not resort to the class list for this, however.

Nor need the University staff be charged with any unlike methods of selection. Although not personally acquainted with all characteristics of their students, the instructors do not fail to use their powers of observation and readily discern in a man the qualities which mark him of investigative spirit or otherwise. In four years' association they know a student's qualifications for engineering better than he knows himself. Moreover, they know the examination record to be a poor criterion of ability and are inclined to take particular interest in the man who views the class list with an air of disdain for five-sixths of the academic year and busies himself in the broader channels of observation that are open to him.

SCHOLARSHIPS THAT ARE NEEDED

When the writer refers to the adoption in Kansas University of what is there known as "Temporary Industrial Fellowships," he speaks of one of the foremost progressive movements of the age. Did Kansas lower her status as a University by unlocking her laboratories to aid the manufacturer in converting wasteful methods into scientific enterprises? The answer is in the success of Professor Duncan's undertaking. It defines Kansas University as an institution devoting its store of scientific resources to a useful purpose that replaces rule of thumb by its own product—

established scientific principles, utilitarian in character, and baneful towards universal waste.

Too many manufacturers have gone to a great deal of expense, with no important results accruing therefrom, in endeavoring to improve methods of manufacture, traditional processes, wasteful and inefficient. They should be better aware of the value the laboratories of the University, with unlimited possibilities in the way of scientific knowledge, extensive apparatus for the investigation of the untried, and men with whom it has thoroughly familiarized these resources. A better acquaintance would eliminate many drawbacks with which their organizations must contend. The sooner the University on its part hearkens to the special needs of industry the sooner it will serve its country to the best of advantage.

Referring again to the letter, although the writer is not prone to look optimistically upon the prospect of fruits from our own research scholarships at present being put under way, he has summed up many valuable points that will clarify in the minds of all concerned and ultimately establish more confidence where forebodings may heretofore have prevailed in the graduate body. We invite the opinions of others for the same purpose.

SCHOLARSHIP APPLICATIONS

It is expected that two scholarships will shortly be awarded by the University of Toronto Engineering Alumni Association, and that all preparations will be made for the successful candidates to begin their preliminary work, before the term opens in October. The interest that has been taken by the graduates in this movement pronounces it one of the greatest that any graduate body has ever undertaken for the benefit of science in general and a few of its members in particular. Nor has the movement been considered lightly by those in a position to undertake the work of experimental research. Quite a number of applications were received and they are undergoing fullest consideration at the present time by the scholarship committee and by the members of the staff concerned. The absolute necessity of careful selection and proper judgment in the awarding of the first scholarship has determined the committee to leave no part of their duty undone.

The applications themselves are for the most part well drawn up, displaying a conception on the part of each applicant of all that has already been done on his subject, and a realization that he is undertaking, if accepted, a very important work.

No definite awards can be made for some time yet, but the next issue of "Applied Science" will contain information as to what has been done to date.

A. W. Youell, '10, is with the Canadian Ingersoll-Rand Co., at Sherbrooke, Que.

OBITUARY

Readers of "Applied Science" have been shocked to hear of the sudden death of Cecil B. Smith, Ma.E., senior member of the well known firm of Smith, Kerry & Chace, and of a number of subsidiary power organizations operating throughout Canada. Mr. Smith had a world-wide reputation in the field of hydro-electric development, and the engineering profession has lost one of its foremost civil engineers. Mr. Smith graduated in 1884 from McGill University, receiving the Governor-General's medal. His prominence in the work of technical societies is universally known.

The School is unfortunate in losing one of its prominent graduates, in the person of Frank T. Conlon, a graduate of '02, who passed away on July 10th, after a long illness. For some time previous to his death Mr. Conlon was a member of the engineering staff of the Welland Canal. When enrolled in the School he was a member of the class in mining engineering.

The article entitled "The University of Toronto and the Mining Industry,'" the first part of which appeared in the June issue of "Applied Science," will be continued in the August number. The writer, Professor Haultain, was out of the city on a business trip while this issue was being made up.

The Vulcan Fellowship in Engineering founded by the Vulcan Boiler and General Insurance Co. in the Victoria University of Manchester, is open to graduates of this Faculty. The Fellowship is of the annual value of £120, and is for research in mechanical and electrical engineering. "Applied Science" will give further information to any one interested.

The Canadian Committee of the International Road Congress, has recently been formed with a view to represent the Dominion at the convention in London next year. Dean Galbraith is president of the newly-organized committee.

C. W. Dill, a member of the civil engineering class of '91, and a member of the firm of Dill, Russell & Chambers, contractors, recently received an appointment to the Board of Highway Commissioners of Saskatchewan.

If readers who have not received binders for Volume V. of this journal, November, 1911, to April, 1912, will notify us at once, their orders will receive attention. These binders are sent free to all paid subscribers.

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